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He who plants a tree
Plants a hope.
Rootlets up through fibers blindly grope;
Leaves unfold into horizons free.
So man's life must climb
From the clods of time
Unto heavens sublime.
Canst thou prophesy, thou little tree,
What the glory of thy boughs shall be?

—Lucy Larcom.

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VITALIZING THE CLASSROOM: SLIDES, FILM-STRIPS, AND FILMS

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Lantern slides, commonly referred to as slides, are transparent photographs or drawings. They differ from other pictorial materials in that they are projected on a screen by means of light passing through the slide. Slides for school use are of two sizes: the standard slide ($3\frac{1}{4}'' \times 4''$), and the miniature slide ($2'' \times 2''$). Both sizes are obtainable in both black-and-white and in color. Some teachers prefer to classify slides on the basis of whether they were produced by photography or were drawn by hand. The $2'' \times 2''$ slide is usually produced by photographic means because the area of the picture is quite small. Handmade slides are usually prepared on standard slide materials.

The criteria for the selection of slides should be the same as the basic criteria set up for other pictorial materials. However, since slides are greatly enlarged when projected on the screen, the technical quality of the photograph or drawing must be considered carefully. Imperfections, to small to be seen in an ordinary unprojected picture, will show up clearly on the screen. In addition, the mounting of the slide must be examined. If the slide is to see a great deal of use, the mount should be between two plates of glass and should be securely taped around the edges. The cardboard mounts used for $2'' \times 2''$ slides are not very satisfactory for class use. Fingerprints and scratches soon spoil an excellent piece of instructional material.

The general principles of utilization and the suggestions made for the use of flat pictures in a previous article all apply in the methods of presenting slides to the science class. Slides are one of the first types of projected pictorial materials to have been used for science

instruction, and the development of newer types of materials has not diminished the value of this important class of teaching aids. The possibilities for making and using slides as visual aids in a unit are great, and the resourceful teacher should capitalize on these values.

The filmstrip for class use is much like the slide. Although there are two sizes of filmstrips available, the type which has become standardized for school use is the single-frame type. Most miniature cameras which take $2'' \times 2''$ slides may also be used to produce a strip of pictures. However, these will usually be double-frame in size and will not be usable on most filmstrip projectors. The cost of filmstrips is reasonable enough so that the teacher will find it more economical to purchase the strip than to try and produce it himself. However, if the proper equipment is available, filmstrips are very easily produced by any science teacher with a working knowledge of photography.

Filmstrips are different from slides in one important respect. The pictures in a filmstrip are in a fixed order, whereas the pictures in a slide series are flexible and may be used in any order desired. This fixed sequence may be an advantage in one situation and a disadvantage in another. Filmstrips are more compact than slide series and may be stored more conveniently in the small cans in which they are purchased. Glass-mounted slides are subject to breakage, but filmstrips may also be damaged in the projector or in handling.

An integration of the filmstrip and the motion picture has made its appearance in science materials recently. Filmstrips have been produced so as to correlate closely with certain motion pictures. The pictures in the filmstrip are carefully selected from the key scenes in the film. The teacher may use the filmstrip to introduce the motion picture, to discuss the key concepts in the film, and to review and test the learnings of the pupils. This offers a worthwhile and interesting approach to the use of motion pictures in instruction.

Another interesting development in filmstrips is the entry of several major textbook publishing companies into the field of filmstrip production. These filmstrips are designed to be used with a specific text published by the company. They attempt, in these productions, to correlate the visual presentation in the filmstrip with the material found in the textbook. This is an extremely important development for, as most teachers realize, the problem of finding suitable pictorial materials to integrate closely with the science units in the textbook has been a considerable problem in some instances. If this idea is adopted generally, the field of instructional materials will have taken a great stride forward.

The criteria for the selection and the principles of utilization for filmstrips are much the same as for other types of projected materials. Filmstrips have certain properties which give them an important

place in the classroom. In their uniform organization and inflexible presentation, filmstrips approach the motion picture in their method of utilization. They have much to contribute to orderly classroom procedure and should not be overlooked in planning the materials for a unit of science.

Motion pictures, because of their interesting property of presenting objects or ideas in motion, deserve a somewhat more detailed discussion than other forms of projected materials. The chief values which the science teacher can obtain from the use of motion pictures are as follows:

1. Motion of plants and animals in their natural environments can be shown.
2. Motion of processes too slow to be seen normally may be viewed.
3. Motion of processes too rapid to be seen normally may be viewed.
4. Motion of objects too minute to be seen without a microscope can be shown.
5. Operations and actions too complex to be understood easily may be explained by animation.

In the utilization of motion pictures several approaches have been tried. As yet, it would be difficult to say that there is only one method of using a film in a science class. Motion pictures fall into a number of different classifications. Certainly, a film designed to teach a specific skill must be used differently than one for the presentation of general background materials. Educators who have studied the value and use of films in the classroom feel that there are many ways of using a film effectively. The type of film, the conditions under which it is used, and the purpose for using that material will all influence the method of presentation.

In the selection of motion pictures the general criteria already discussed should be followed. In addition, the technical quality of the film and its use of sound and color must be evaluated in relation to the teaching objectives. The pace of the film should be such that the grade level in which the material is to be used will be able to profit from the lesson. The film should capitalize on the unique potential of this medium by showing most scenes or concepts *in motion*. And the motion should present its lesson in such a way so that no other form of instructional material could be employed to replace that presentation.

A good lesson involving motion pictures takes careful preparation on the part of the teacher. The first step is to preview the film. Next, the study guide, usually furnished, should be analyzed. Third, the projection equipment and the physical facilities of the classroom must

be inspected. And fourth, the objectives to be gained from the use of this material must be reviewed. In preparing the class, the general purpose of using the film must first be discussed. The vocabulary terms which may not be understood by the class should be listed and explained. The main ideas presented in the film and the main concepts and observations which the pupils should be able to gain should be listed on the chalkboard for later reference.

The presentation of the film should take place as a normal part of the science activity in the regular classroom, if at all possible. Immediately after the screening is over, questions fresh in the minds of the pupils should be discussed. If possible, the film should be reshown following this brief discussion period. If that is not possible, the showing may be repeated again the next day. In any case, a film should be screened a second time if the class would seem to be able to profit from this second presentation. The follow-up activities may cover a wide range of action. A few of the more commonly used activities would include allowing pupils to write summaries of the main ideas shown in the film, using a short test to see whether the concepts presented in the lesson have been properly understood, discussing the questions listed previously on the board in light of the film learnings, encouraging pupils to carry on additional activities related to the ideas presented in the film, and making or bringing in other instructional materials to emphasize the major generalizations visualized in the motion picture.

DIRECTORY OF SECONDARY SCHOOLS

Since the school year 1912–13, ten directories of accredited secondary schools have been issued by the Office of Education. Beginning with the school year 1945–46, a new series was started, designed to include *all* known high schools, both accredited and unaccredited. This volume is the second in the new series.

In this Directory, the listing of public secondary day schools is, so far as we know, complete; the listing of nonpublic secondary day schools is not quite complete, but all *accredited* nonpublic day high schools are included. A new feature in this Directory, rendered desirable by the increased number of United States citizens and families in foreign countries, is the inclusion of all secondary schools abroad which are accredited by a regional accrediting association in the United States.

Information given for the various schools includes: type of organization of school; race served; number of years in school; accredited status of school on the State and regional levels; total professional staff; and total enrollment—all for 1951–52; and number of graduates for 1950–51.

Further issues of the Directory, which should be of service to a wide variety of users, are planned at intervals of about five or six years.

"Directory of Secondary Day Schools, 1951–52." By Mabel C. Rice, Research and Statistical Standards Section, Office of Education. 169 pages. 1952. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. $1.00.

CARE, USE AND REPAIR OF LABORATORY EQUIPMENT*

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Mr. Chairman, members of the Central Association of Science and Mathematics Teachers, it is a pleasure to appear before this group and speak on a subject which comes within a field I have been interested in and working in all of my professional life, that of physics. The subject assigned me is a perfectly harmless looking one, but as the time approached to formulate some thinking on just what to say it has turned out to be one which is difficult so tet down in precise statements. The use of laboratory equipment is covered in many textbooks written especially for the high school laboratory. Manufacturers of laboratory apparatus supply instruction sheets covering the use of equipment. Instructors through their normal everyday contact develop techniques in the use of equipment. This particular aspect of the subject might have been passed off quickly by saying it is one with which we are all generally familiar. However, proper use is tied in so closely with care and maintenance of the instruments and apparatus used in the physics laboratory, the discussion of one involves discussion of the others.

It is often stated but I do not believe the statement is made too often that a course in high school physics is extremely important in the development of the mental processes of young students. The formation of his mental habits and attitudes is dependent on the disciplines taught in physics, chemistry, mathematics and the other sciences. I hope that those who control our high school curricula, who are spending their time in developing what these curricula shall be, are not losing sight of the importance of a course in physics, mathematics, chemistry or the other sciences. It may be true that the student is not able to work all of these into his high school program, but those of his choice can and should be a part of his high school training. The carry-over into college, if he should be one who decides to go to college, will be of extreme help in rapid advancement in these fields of study.

What the student gets in his high school course depends to a large degree upon his instructor. Textbooks and laboratory manuals are available to him, but the instructor is the one that sets the pace. In addition to the instructor, textbooks and laboratory manuals, classrooms, laboratories and libraries are needed. These play a role in the care, use and maintenance of physics apparatus.

* Presented at the Physics Section of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, Chicago, November 28, 1952.

Textbooks and manuals available seem to be adequate. While many of them are lowering the level of physics unnecessarily, several good ones exist. I wonder if we as teachers, educators, administrators and laymen fail to evaluate high enough the mental intelligence of our young people. In some countries a youngster at sixteen years of age knows of physics what our college graduate with a major in physics knows. Through the use of physics instruments and apparatus we should be advancing the knowledge of physics at a much more rapid rate than we are today.

An instance happened while I was a graduate student in physics which I wonder if doesn't happen often to many of us. I was a graduate assistant taking graduate courses and at the same time instructing in the undergraduate laboratories. The duties of the graduate student included setting up of laboratory experiments and seeing that the apparatus met the requirements expected of it. One afternoon I was in the department head's office and a fellow graduate assistant who had been working in the sophomore laboratory came in, explained some difficulty he was having, and said the apparatus just didn't work. The department head, having years of experience with laboratory apparatus, said he wouldn't accept such an explanation as a final answer. He told the graduate student that had he confessed he couldn't make the apparatus work it would be entirely acceptable, but to put the blame on the apparatus, in his mind, was starting off on the wrong foot.

Could the attitude that the apparatus won't work be the cause of much of our laboratory troubles? It takes a lot of time, patience and experience to run a physics laboratory successfully and to conduct demonstration lectures in physics. Time spent in the subject naturally brings experience. Patience is a thing that all teachers of physics must have. For one who will meet these qualifications, good apparatus techniques should and will follow.

In physics we teach something about mechanics, heat, sound, light, electricity, magnetism and nucleonics. Much of what we teach is taught by having the student see and do. This requires the use of apparatus. Since many different experiments are performed during the course of a semester's work, requiring a considerable quantity of equipment, the laboratory and the lecture room should be provided with an apparatus storage room. A place under the lecture table or under the laboratory table is not sufficient. The storage place must be planned, well planned, and kept in good order. There must be a place for everything and everything in its place. Apparatus used in the mechanics laboratory should be kept to itself, and as far as possible the apparatus required for each experiment kept together. Likewise for the apparatus used in the various experiments in sound, heat,

light, electricity, magnetism and nucleonics. The best arrangement will require duplications of apparatus, and duplication should be made as far as possible wherever possible. Equipment of frequent use such as trip scales, analytical balances, calipers, meter sticks, clamps, rods, measuring microscopes, barometers, electrical meters, rheostats, resistance boxes will be needed in greater duplication. They must be more readily available and stored nearer at hand than the less frequently used equipment.

Laboratory apparatus has an indefinite life when properly cared for, properly used and properly maintained. I know of a case where a fire insurance company paid 98% of the current replacement cost of all physics equipment destroyed in a laboratory fire even though some of the equipment destroyed was thirty to forty years old. The claimant argued that the usefulness of physics equipment does not deteriorate when the equipment is cared for and maintained properly, and he won his argument.

It seems to be human nature to assemble and operate a new piece of equipment without first reading the assembly and operating instructions. This apparently is true whether it be a new device for the home or for the laboratory. Many times this is disastrous. Being one associated with a company manufacturing physics instruments and apparatus, I cannot recommend too strongly first reading the assembly and operating instructions before operating the piece of new equipment. I believe you will find that all manufacturers supply such instructions with each and every piece of apparatus. A few minutes taken in the reading and understanding of them will save many repairs and will make the maintenance of the equipment easier.

Standardization in use and manufacture of apparatus has resulted in many uniform procedures and practices amongst teachers and other users of physics equipment. Manufacturers have adopted standard size rods, clamps and component parts of equipment. This has contributed to simplified use, maintenance and repair. Also it helps the manufacturer when he receives for repair apparatus not of his own make. It helps the instructor who desires to do his own maintenance in securing standard replacement parts or even in making his own replacement parts. Standardization usually carries with it simplification.

Every physics laboratory should have associated with it or available for its use some repair shop facility. This may be no more than a simple set of tools and a vise and a drill press. Even better but not absolutely necessary would be a modestly equipped machine shop. The instructor who is fortunate in having a machine shop has at hand all the tools necessary to make up many things special for his own use. The creative teacher of physics always will desire special

equipment not provided by the apparatus manufacturer.

At the close of each semester's work, oftener if possible, each piece of equipment should be examined for possible damage, and when repair is necessary it should be made immediately rather than postponed until the next time the equipment will be used. The equipment then can be stored away ready for use on short notice.

In many high schools the care and repair is the sole responsibility of one instructor. This has its advantages where the amount of equipment is small enough that one man can handle the repair as well as the use. He then knows what is to be done and is responsible only to himself for doing it.

The manufacturer designs and produces physics apparatus to withstand hard usage in the inexperienced hands of students. It is natural to expect laboratory equipment to be subjected to hard usage, but even with the best of design and produced in the most rugged manner possible, equipment will need frequent inspections for damage and will require repair. Such precautions as fusing electrical meters, requiring a check of the electrical circuit by the instructor before electrical power is applied, in fact requiring a check of each experimental setup before the student begins his experimental work, will save on maintenance and will simplify the problems of care and repair.

In the laboratory and in storage, physics instruments and apparatus should be protected as much as possible from the dust and dirt which naturally are present. This is particularly true of optical and electrical equipment. Such protection during storage can be provided by adequate cases, and, when equipment is set up in the laboratory, by covering with cloths when the laboratory is not in session. Rust and corrosion of metal parts are enemies of good maintenance, particularly during long storage periods. A little oil applied to surfaces which may rust or corrode or which need lubrication for running purposes will preserve equipment and extend its useful life. Petrolatum thinly applied provides an excellent film for rust and corrosion prevention on metal surfaces. Glass stopcocks and glass stoppered bottles are a constant source of irritation around the laboratory. The stopcock if not checked frequently for good lubrication will freeze and then more time is wasted in getting the stopcock back into service than ever would be used in maintaining its proper lubrication. For storage it is best to clean all stopcock grease from glass stopcocks. Be sure, however, to insert a fine sliver of paper between the stopcock plug and bore before reinserting the glass plug into the bore.

Chemicals can be kept best in their original packages stored in a clean, dry place. Prepared solutions should be stored in well-stop-

pered bottles in a clean, dry place, keeping in the laboratory only enough of each solution to meet the needs of the laboratory group. Most chemical solutions used in the physics laboratory have long useful lives and even may be kept from one semester's use to another.

Optical equipment requires special attention and constant supervision. Much optical equipment is precision made which affords excellent opportunity to instruct students in the proper handling of delicate precision apparatus. It is important, too, that in storage optical equipment be protected from dust where lenses and other optical surfaces are in danger of collecting dust and dirt, making possible the damage of these surfaces upon cleaning.

The use of apparatus and a good knowledge of experimental physics are tied closely together. One depends upon the other. The laboratory experiments can be selected and designed best for an even front, that is, enough sets of apparatus are utilized to enable the whole class to work in small numbers on the same experiment or enough different experiments be set up which permits a small number of students on one experiment and rotating the class through the sets of experiments. This makes it possible to use apparatus which is of a simpler and less expensive type. Occasionally when experiments are inserted for completeness which by their nature require a more expensive piece of apparatus a demonstration laboratory period may be substituted.

The importance of physics is realized when we stop to realize that physics is playing an ever-increasing part in shaping our environment and our mode of living. Were it not for the knowledge and application of the laws of physics, one could not travel through space, ride under the sea, or even on the sea, view the hitherto unknown celestial bodies, or examine the minute forms of life and matter. Present-day labor-saving devices, the electric light, the many electric home appliances, the automobile, television, telephone, are often taken for granted and little thought is given to the years of scientific research which produced them. What is the fascination which makes great minds devote years of study to physical phenomena in order to present to the world wonders which all too soon will be labeled necessities? Is it not because there are always untold possibilites ahead, a story of surprises awaiting? These great minds begin somewhere, and usually the early development of them is while the physical body is still young, so as far as physics and the other sciences the high school instructor has in his hands these great minds first. Instilling into them the proper care, use and maintenance of the tools they will use for the rest of their lives is a worthwhile, essential and honorable endeavor.

A SIMPLE GLASS TUBE CUTTER

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A simple device for cutting glass tubing of diameter greater than $\frac{3}{4}$ inch is shown in Fig. 1. The apparatus consists of a small wire suspended between two points and looped around the piece of glass

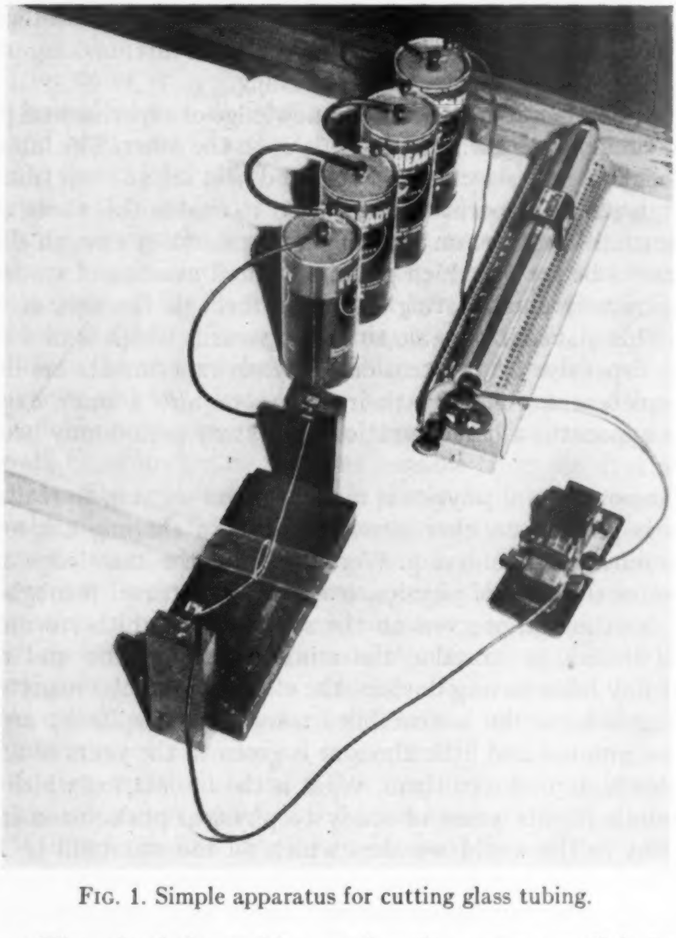

FIG. 1. Simple apparatus for cutting glass tubing.

to be cut. The wire is heated by an electric current until it becomes red-hot. A small amount of water is then poured over the wire and glass. The glass immediately breaks at the desired point.

Batteries may be used as the source of power to heat the wire; however, a more satisfactory method is to use a variable type transformer capable of delivering the necessary power. In the apparatus shown, about 6 amperes of current is sufficient to heat the wire to

be red-hot. The voltage needed will depend upon the resistance of the wire used.

ELEMENTARY SCIENCE TEACHING HINTS

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Some Experiments with Air and Air Pressure

The laboratory phase of science is the feature that distinguishes science from the other subject areas. Remove the laboratory activities from science and it becomes just another course about something. We are interested in helping pupils learn science and not in helping pupils learn about science, hence laboratory activities are important. Laboratory activities for activity sake are not of much avail to the pupil. Laboratory activities, like all other instructional procedures, must have a purpose.

First hand experience opportunities can be provided for children of all ages. Some concepts concerning air and air pressure and individual experience opportunities that have been found helpful in giving meaning to these concepts are given here. These activities may be carried out on an individual or group basis.

Air is all around us.

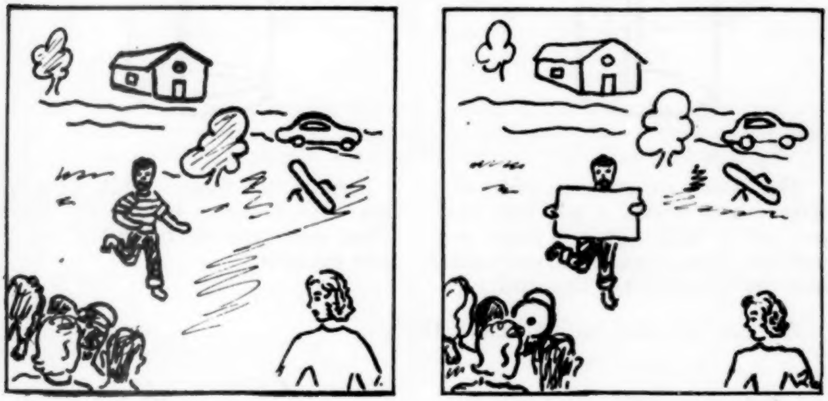


Fig. 1

Several children may run across the playground.

The same children will now try to run across the playground while holding a large piece of cardboard in front of them.

The results of the two experiences will be compared. When was it the easiest to run, with or without the cardboard? What held you back?

Air takes up space.

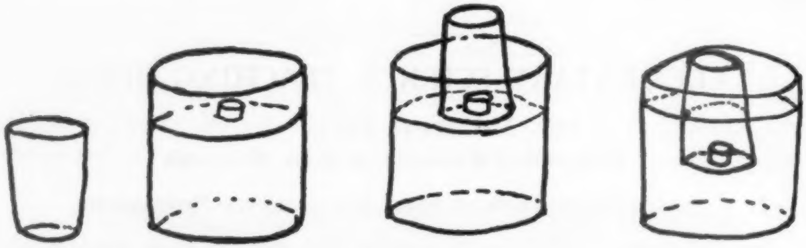


Fig. 2

Examine a tumber. Is it empty? Can you see anything in it?

Place a cork in a vessel of water. Invert the tumbler and force it down over the cork into the water. What happens? Was the tumbler empty? What was in the tumbler? Does it take up room?

Fig. 3

The above apparatus consists of a large mouth bottle, a two hole stopper, and a funnel. Place a finger over one hole of the stopper and pour water into the funnel. What happens?

Remove the finger. What happens now? What comes out of the hole? What goes into the bottle? Does air take up room?

Air can be used to lift heavy things.

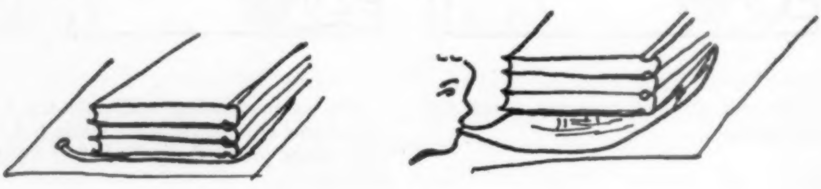


Fig. 4

Place a balloon under a pile of books. Blow into the balloon. What happens? What is lifting the weight?

Air fills every space not filled by something else.

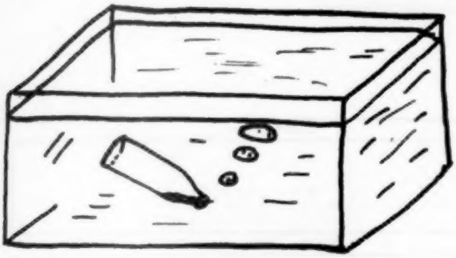


FIG. 5

FIG. 6

Place an "empty bottle" under water. What happens? What comes out? What goes in? Was the bottle empty? What did it have in it?

Punch a hole in the cover of a box. Push the cover down on to the box. What happens? What comes out of the hole? Was the box empty? What was in it?

FIG. 7

FIG. 8

Try to pour water into a narrow necked bottle. What happens? What was in the bottle?

Open a grocery bag and look in it. Twist the top tight shut and tie with a string. Lay it on its side and place a book on the bag. What happens? What holds the book up? Was the bag empty?

Air has weight.

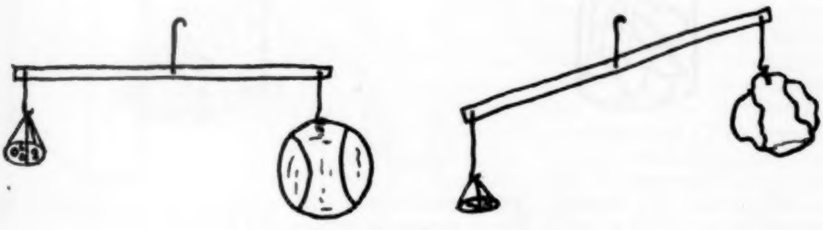


FIG. 9

Balance an inflated basketball or balloon. Let the air out of the basketball or balloon. What happens? What escaped from the ball or balloon? How could it be balanced again? Does air weigh something?

Air takes up moisture.

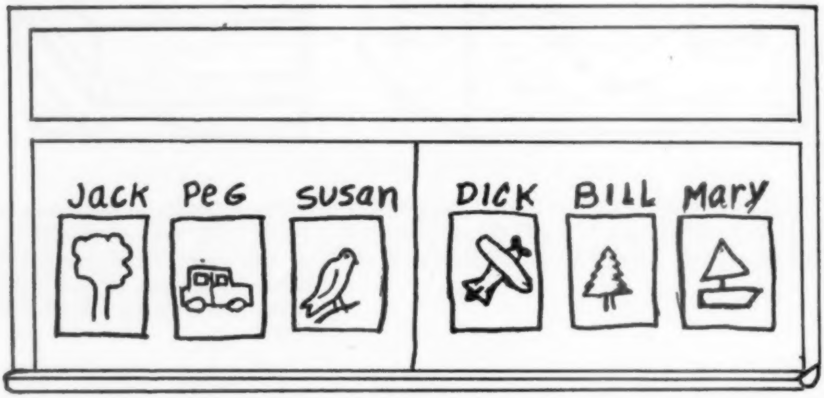


FIG. 10

Paint water pictures on the chalkboard. What happens? Where did the water go?

FIG. 11

Wash some doll clothes or paint cloths and hang them up. What happens? Where did the water go?

Air gives up moisture.

FIG. 12

Fill a clean dry tumbler or polished vessel with cracked ice and allow it to stand for a period of time. What happens? Where did it come from?

Soil contains air.

FIG. 13

Place a quantity of soil in a container.

Fill the container with water. What do you see coming to the surface of the water? Where did it come from?

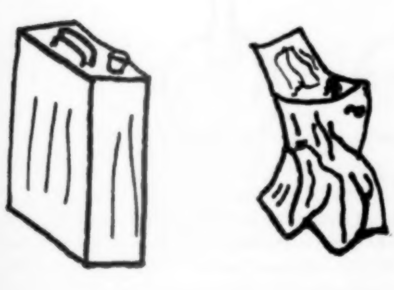
Water contains air.

FIG. 14

Pour a quantity of tap water into a tumbler and allow it to stand for a period of time.

What forms on the sides of the tumbler? Where did they come from?

Air pressure is noticed when it is unbalanced.



Pour a small quantity of water into an empty tin can. Heat the water until the steam escapes freely from the opening. Remove the can from the heat and stopper tightly. Cool the can by pouring cold water over it. What happens? What did the cold water do to the steam? Where was the pressure greater? Were the sides of the can pushed in or sucked in? (This experiment may be performed by exhausting the can with a vacuum pump or aspirator.)

FIG. 15

Air pushes in all directions.

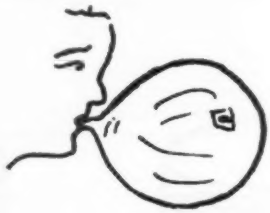


FIG. 16

Blow up a balloon. Does it get bigger in one direction or in all directions? What is pushing on the inside? What is pushing on the outside? Does it push in one direction? Does it push in all directions?

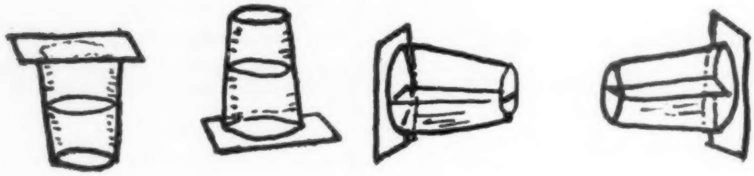


FIG. 17

Fill a tumbler with water and cover the opening with a piece of heavy paper. What holds the paper over the glass? Invert the glass and paper. What happens? What holds the paper over the opening of the glass? Hold the vessel in several positions. What holds the paper over the glass in each position? Does air push in one direction or in all directions?

Air expands when heated and contracts when cooled.

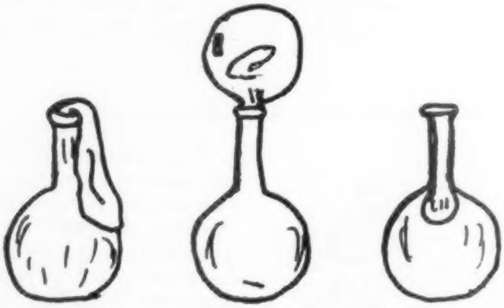


FIG. 18

Place a balloon over the mouth of a vessel (a pyrex glass or metal container is best). Heat the container. What happens? Is the container still full of air? What is in the balloon? Where did it come from? What happens to air when it is heated? Place the container in cracked ice. What happens? Is the container still full of air? What is in the balloon now? Where did it come from? What happens to air when it is cooled?

Warm air is lighter than an equal volume of cold air.

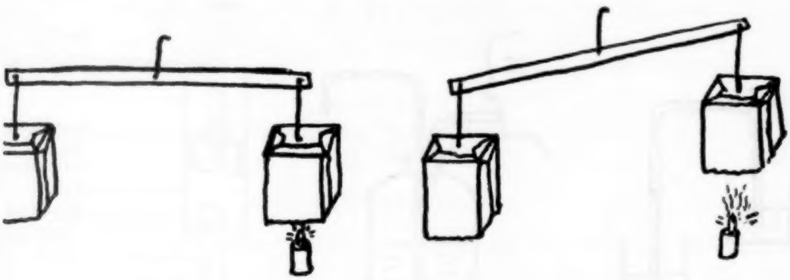


FIG. 19

Two common brown paper bags are suspended open end down and balanced. A burning candle is placed under one bag. (This heats the air.)

What happens? Which bag is heavier? Are they both full of air? Place your hand in each bag. What do you notice? Which is heavier warm or cold air?

Air supports balloons.

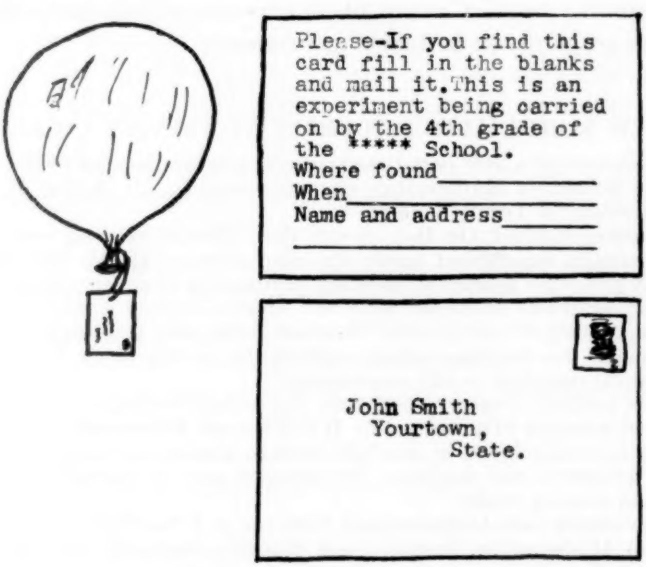


FIG. 20

Fill toy balloons with hydrogen and tie them tightly to reduce gas loss to a minimum. Attach a postal card containing the information as given above. After each child has had an opportunity to have a balloon or two filled and has prepared the necessary postal cards go to an open area and release the balloons with the cards attached. Is hydrogen heavier or lighter than air? What makes the balloons go up? What pushes the balloons along? What is wind? Why can't we just blow up the balloons with our mouths? (This activity provides an excellent introduction to buoyancy and also opportunities to include some geography. Some of these balloons have been known to travel several hundred miles.)

Man uses air in many ways.

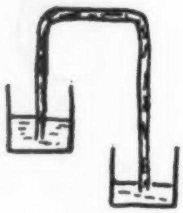


FIG. 21

FIG. 22

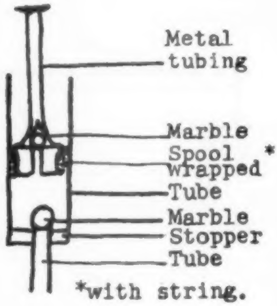


FIG. 23

These are but a few of the many activities that may be carried on when studying air. Any activity that helps pupils to learn science from first hand experience is important and worthwhile no matter how simple it may seem. Usually the simpler the equipment and procedure involved the more effective the experiment.

Why don't you start a card file of experiment demonstrations, and activities to help you in teaching science?

NEW MATHEMATICS COURSES AT TRINITY COLLEGE

Establishment of a new part-time graduate program leading to the degree of Master of Science in Mathematics was announced by Dr. Arthur H. Hughes, acting president of Trinity College.

In his announcement, Dr. Hughes said that "Trinity has long been noted for its mathematics department under Professor-emeritus H. M. Dadourian and since 1949 under Dr. Harold L. Dorwart, particularly in undergraduate preparation of actuaries and scientists. With the large number of engineers and scientists now coming to our greater Hartford industries, it is appropriate that Trinity make this teaching talent available to develop more fully the adult mathematical potential in the community."

The new program is open to both men and women holding a bachelor's degree with a concentration in mathematics. It will include 30 semester hours of graduate study in such subjects as analysis, modern algebra and matrix theory, differential geometry, and statistics. The program may be completed in three to six years of evening study.

Courses offered include Operational Calculus, and Trinity's unusual course in Numerical Mathematical Analysis and Machine Methods. The latter course teaches use of the "electronic brain" computing machines which have permitted mathematicians to solve the extended problems of jet engines, radar, atomic fission, and other developments in modern science. Computing laboratories of United Aircraft are loaned to Trinity on Saturdays, thereby permitting Trinity to be the nation's only small college to offer such a course.

Photoflash exposure guide fits the palm of the hand and gives accurate exposure settings for cameras using flash attachments, regardless of the distance from the flashbulb to the subject. The device works no matter what combinations of flashbulb and film are used.

THE PLACE OF MATHEMATICS IN SECONDARY EDUCATION*

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I. INTRODUCTION

By definition, secondary education includes the work of the junior high school, the senior high school, and the junior college. The development of the junior high school since 1915 and the reorganization of the senior high school and junior college to fit in with this development has stimulated further investigation along two main lines. The first is the determination of the proper curriculum and the second is the improvement of the quality of instruction throughout the secondary school. Each of these two lines of investigation has raised a large number of questions in the minds of teachers and administrators alike. The answers that are now being given to these questions will determine the degree of success or failure of the new type of secondary school that emerges. These answers are not only evolutionary but to some extent revolutionary, especially in regard to certain points.

We need further study on the most important problems that have been considered in the last thirty or forty years, on the main conclusions that have generally been reached, and on some of the methods that will make such study properly effective. The National Council of Teachers of Mathematics should set up a national policy and platform giving the place of mathematics in modern education, the nature of the best curriculum in mathematics for the secondary school, the best methods of instruction, and a sensible evaluation program for the same. In addition, the platform should set forth how the study of mathematics may be made more real, interesting, and valuable to the students who have to study it.

If properly organized and carefully taught, no subject in the secondary curriculum should ever seem dull or uninteresting. This is particularly true of mathematics. Even if a group of slow learning students is unable to keep pace with the more gifted members of the class, they can, if the work is carefully organized and taught, be led to enjoy and understand the mathematics that is presented to them. More time may be needed and they may not be able to comprehend as much as their classmates, but they can learn a great deal from the course. Similarly, the more gifted students should be given work of

* A paper read to the Mathematics Section of the Louisiana Education Association in New Orleans on November 25, 1952.

interest to their higher intelligence and worthy of their superior powers. As things now stand, the standard of teaching is too often set by the demands of mediocrity. We need a curriculum in mathematics for the secondary school that will contain enough suitable material that will test the best of the gifted students which, at the same time, will contain material simple enough for the slower students to comprehend and yet adequate to meet the needs of the ordinary citizen of a democracy. The administrative problem is somewhat different in the large city and smaller town[1] schools and it is not easy to solve, but it is a challenge to the best thinking we can do.

The professional literature in the field of mathematical education in particular and pedagogy in general is unusually rich and extensive. In the last three decades alone, there are several thousand references available, including books, monographs and unpublished theses, as well as periodical references. To be sure, not all of this material is equally useful or readily accessible. Much of it, however, is of considerable interest and value to the experienced teacher of mathematics and more especially to the student teacher.

Most students in the secondary school and many of their parents have continually asked "Of what use is mathematics to me?" or "What use can I make of mathematics in later life if I spend time studying it beyond the rudiments of arithmetic, which generally are recognized to have practical value?" Mathematics has many uses, but not all of them can be brought into the classroom.

The question "Why study mathematics?" is as important as it is natural and legitimate, and deserves an honest and forthright answer. The subject has been studied ever since man began to think in abstract terms, to create for himself and for posterity units of measure that developed more and more uniformity as time went on, to think of time, and to develop geometrical concepts like lines and angles. All people not only have a right to know the answer to these questions, but, with a little study and interest, they can understand the nature, purpose, and value of mathematics in a general way.

How many teachers of mathematics reading the questions above are able to give clear and satisfactory answers even to themselves? Upon the answer to these important questions, depends the solution of many of the problems relative to the content and methods of teaching and learning the subject. The current agitation concerning the place of mathematics in modern education demands that each teacher of mathematics be able to answer these questions intelligently. Not much can be learned by the type of student who in substance says to his teacher, "Interest me, will you?" In order to understand the value of mathematics, one must spend some time studying it,

[1] Price, H. Vernon, "The Small Town High School," *The Mathematics Teacher*, October, 1952, 45: 406–407.

as he does any other subject, and he must assume some degree of interest in it.

How important is mathematics? If one has never failed the subject, or has never had any unfortunate experience with arithmetic, algebra, geometry, or any other branch of mathematics, he may be inclined to agree with those who say that mathematics is an important subject which should be made available (though not necessarily required) throughout the secondary school. If, however, because of failure or poor teaching, or mere lack of interest, he has not seen any of the beauties of mathematics, he will probably agree with those who say that mathematics, beyond the bare essentials of arithmetic, should not be included, much less required, in the secondary school.

It certainly would be interesting, and perhaps enlightening, if some person or group of persons were to find out how many of all those who advocate the curtailment of mathematics, if not its actual elimination from the schools, take that stand because of some unhappy experience with the subject one way or another. Some studies have been made to ascertain why students like or dislike certain subjects. They have shown that in many cases students like or dislike a subject (and mathematics is no exception) because they liked or disliked the teacher in question.

What high school students think about mathematics. Fortune Magazine[2] made a survey of public opinion called "How Popular Is Mathematics Among High School Pupils?" (A two-part self-portrait of American high-school youth . . . what it thinks of itself, its country and its future.) What these boys and girls thought of the subjects they had been studying in school should be of interest to the teachers of the various subjects presented. What they thought of mathematics should be of particular interest and profit to us here.

In commenting on the results of their survey *Fortune* said:

"There's no mystery about the fact that English and mathematics rank, respectively, first and second as most liked *and* most disliked. In the first place they are the most universally given, and run generally through all four years of school. But cross tabulation shows very clearly that there are two kinds of students whose preferences form consistent patterns. Those disliking English, language, and history are devoted to mathematics and the laboratory sciences; and vice versa."

Here is a challenge for all teachers of mathematics. When students like mathematics they like it very much. When they hate it they hate it with a vengeance. Why this great gap?

Who should study mathematics? In these days, when one hears so

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[2] *Fortune Magazine*, November and December issues, 1942.

much about the importance of mathematics in the education of American citizens, teachers of mathematics should begin to study and discuss the question as to who should study mathematics and how far its study should be pursued by secondary-school students.

There is no question but that students of ability who are interested in the subject should be encouraged to study mathematics throughout the secondary-school period. Even those of so-called *average* ability or above who like mathematics should be encouraged to do so. Moreover, those students who know that they are going into lines of work where a knowledge of mathematics is basic, as in engineering, should be encouraged to continue their study of mathematics as long as they are in school. Our recent awakening to the fact that many students have been deprived of the study of mathematics which they actually needed is evidence of our lethargy in the matter.

However, there is a tendency now in some places to try to force many students to study mathematics beyond their need and ability. It is to be hoped that guidance[3] in such matters will be carefully discussed and planned for all schools.

All of this means, of course, that better organization and methods of teaching mathematics are now more important than ever, if mathematics is to continue to occupy the position of high importance which it has held throughout the years.

The schools are now confronted with the problem of deciding what they can do to improve the mathematical abilities of those students and others in the community who are almost certain to need mathematics in their life work. It is only fair to say that some teachers are taking the situation seriously while others, if not completely apathetic about it, are doing little or nothing constructive so far as one can observe from the outside.

The fact that mathematics is so important is not surprising to one who is properly informed as to the contributions which it has made to the other great fields of knowledge, but many people, including some of the general educators, are still unaware of the strategic place which mathematics really occupies in world affairs today. It should be the business of those of us who are interested primarily in the subject to help to make clear just where and how mathematics can be of real service to the other great branches of learning and what can be done to secure these services by a better teaching of mathematics in the schools.

Why is it that so many of our graduates of the secondary school

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[3] "Guidance Report of the Commission on Post-War Plans," *The Mathematics Teacher*, November, 1947, 40: 315–339. The final report of this Commission. Reprinted as a *Guidance Pamphlet in Mathematics for High School Students*, The National Council of Teachers of Mathematics, 1201 Sixteenth Street, N.W., Washington 6, D. C. Price, 25¢ postpaid. Orders of ten or more copies will cost 10¢ each postpaid.

and the colleges today know so little of budgeting, the cost of unemployment, the benefits of foreign trade, the cost of crime and the resulting punishment of the offender, and the cost of taking care of the needy, the insane, and the homeless? One large factor here is the neglect of informational arithmetic[4] all along the line. Too much time has been spent on computational arithmetic, and often of a very low order at that, in so far as the real needs of society are concerned. This situation should be remedied.

II. The Nature, Purpose, and Value of Mathematics

In order to answer the above questions satisfactorily we ought to consider at least two things: first, *the definition of mathematics*, and second, *the purpose and value of its teaching*. Clearness and definiteness of aim in teaching requires that we have in mind constantly these two things.

Just what is meant by "mathematics"? The term "mathematics" is loosely used and is supposed to cover other loosely used terms like "arithmetic" and "algebra" and even terms from higher fields. Moreover, there is not necessarily any correlation between any two parts of mathematics; say computation and some other part. Thorndike said:

"It seems probable that algebraic ability and geometric ability differ nearly if not quite as much as do ability in algebra and ability in any other subject such as physics or Latin."[5]

David Eugene Smith always maintained, "There is no such thing in general as a mathematical mind." He used to tell about a certain great mathematician who said to him, "I do not know anything about computation. I never can figure and have it come out right." Does the term then cover such a wide range that we really cannot expect to train mathematicians as such? Is there no such thing as arithmetic by itself, algebra by itself, geometry by itself, and so on? Is mathematics changing so fast and so much that a definition today may be obsolete tomorrow?

Historically, we know that mathematics was originally ***knowledge***. At the time of Pythagoras, it was perhaps that part of knowledge not including literature and oratory. It has included the theory of numbers, geometry, which itself changed from measurement to scientific study, astronomy, and music, until about four hundred years ago. The name "trigonometry" is only about four hundred years old. Algebra as we know it is only about four hundred years old, and so I might go on.

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[4] Judd, C. H., "Informational Mathematics Versus Computational Mathematics," *The Mathematics Teacher*, April, 1929, 22: 187–196.

[5] Thorndike, E. L., and Others. *The Psychology of Algebra*, The Macmillan Company, New York, 1923, p. 216.

What do we mean by "unified mathematics," "correlated mathematics," "fused mathematics," "general mathematics," and the like? We can never get a mathematics which is based upon the fact that all are called "mathematics." We cannot mix everything in every conceivable way. We must seek out the honest points of contact and unite them in a reasonable manner.

Of the many definitions of mathematics the favorite one seems to be that of Peirce, who said, "Mathematics is the science of necessary conclusions." In speaking of the above definition Young said, "According to this definition those conclusions and no others are mathematical, which must be true, provided the premises are true. In mathematics, granted the premises, the conclusions follow inevitably; outside of mathematics, the granting of all the premises does not necessarily establish the conclusion."[6]

The fundamental question as proposed by Young is, "Does the study of mathematics, the science of necessary conclusions, help the mind to make better those conclusions which do not follow necessarily?" A good discussion of this last question will be found on page 23 in Young's book.

Mathematics is one of the greatest of all the sciences. It was the basis of most of the natural science of ancient times and today is fundamental to an understanding of all science. It enters into every walk of life. It is desirable that students should know what its general nature is, and what people mean when they talk about per cents, algebra, trigonometry, or such things as formulas, theorems, and triangles. Today, one would feel not only his limitations but also his inability to make progress if he did not have control of simple formulas like those found in current periodicals and newspapers relating to air or marine navigation, radio, television, engineering, nursing, and the like. Such an assertion may with equal truth be made with respect to any other great branch of human knowledge. The schools have plenty of time to open the doors to these several branches, or to merge the branches in any way that seems best, so long as they give students this vision and the opportunity to use their inherited powers to the best advantage.

The purpose, therefore, of requiring students to study mathematics is to give them a knowledge of what the science means, and to make it possible for them to continue further in one or more of its branches as their tastes and needs require. Let us remember that it is not the purpose to make mathematicians of all of them, nor even to try to make most of them capable of solving a quadratic equation or proving the theorem of Pythagoras. Moreover, mathematics is one of a

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[6] Young, J. W. A. *The Teacher of Mathematics*, Longmans, Green and Company, New York, 1925.

small group of subjects like reading, geography and history, each of which is related to a large number of the great fields of human knowledge and should be as familiar as possible to all who have the ability to understand it.

The importance of mathematics as it affects our daily lives is a thing about which we have heard a great deal of discussion in recent years. If one should attempt to trace the origin and development of the subject, he would need to follow the struggels of the race from the primitive period up to the present time. Our early ancestors undoubtedly began their simple mathematical calculations because of some pressing need or desire to obtain mathematical results of one kind or another, and subsequent generations have successively builded upon the achievements of their forefathers until now it would be impossible for us to maintain our complex twentieth century life if the mathematics underlying it were to be suddenly removed.

Keyser made a strong case for the place of mathematics in modern education when he said:

"If all these mathematical contributions were by some strange spiritual cataclysm to be suddenly withdrawn, the life and body of industry and commerce would suddenly collapse as by a paralytic stroke, the now splendid tokens of material civilization would quickly perish, and the face of our planet would at once assume the aspect of a ruined and bankrupt world. For such is the amazing utility, such the wealth of by-products, if you please, that come from a science and art that owes its life, its continuity and its power to man's love of intellectual harmony and pleads its inner charm as its sole appropriate justification."[7]

If the sum total of mathematics were to be limited to the immediate demands of the man in the street, no further education in mathematics beyond the junior high school or the ninth grade would be necessary for many people. However, a similar remark could be made with assurance about reading, history and geography, about such sciences as biology, chemistry and mechanics, and about subjects of human learning in general.

The safety factor of mathematics. We need, however, a safety factor of knowledge of mathematics in order that civilization may progress. Man has never been content with a bare minimum in any sphere whether it be food, clothing, shelter, culture, or his thinking. To have rested on his laurels man never would have emerged from barbarism; he always seeks to get more general understanding of the great fields of knowledge. As Browning put it, "Man's reach should exceed his grasp, else what's a heaven for?"

[7] Keyser, C. J. *Introduction to Reflective Thinking*, Columbia Associates in Philosophy, Houghton Mifflin Company, New York, 1923.

Similar questions as to the extent of the pursuit of knowledge arise with reference to the other fields of knowledge. Why should one be able to read when he can listen to the radio or televison? Why should one study geography to learn where London is if he cannot go there?

Many inventions of the human race like those of the pulley, the wheel and axle, the lever and the wedge were not only made early but, according to Jourdain, "were made on the basis of an instinctive and unreflecting knowledge of the processes of nature, and with the sole end of satisfaction of bodily needs." Such activities of primitive men were reflected on no doubt, and as time went on were classified in some more or less scientific way.

As Jourdain put it:

"We can well imagine that this pursuit of science is attractive in itself; besides helping us to communicate facts in a comprehensive, compact, and reasonably connected way, it arouses a purely intellectual interest. It would be foolish to deny the obvious importance to us of our bodily needs; but we must clearly realize two things: (1) The intellectual need is very strong, and is as much a fact as hunger or thirst; sometimes it is even stronger than bodily needs. Newton, for instance, often forgot to take food when he was engaged with his discoveries. (2) Practical results of value often follow from the satisfaction of intellectual needs. It was the satisfaction of certain intellectual needs in the cases of Maxwell and Hertz that ultimately led to wireless telegraphy; it was the satisfaction of some of Faraday's intellectual needs that made the dynamo and the electric telegraph possible. But many of the results of strivings after intellectual satisfaction have as yet no obvious bearing on the satisfaction of our bodily needs. However, it is impossible to tell whether or no they will always be barren in this way. This gives us a new point of view from which to consider the question, 'What is the use of mathematics?' To condemn branches of mathematics because their results cannot obviously be applied to some practical purpose is short-sighted."[8]

III. Traditional Reasons for Teaching Mathematics

Three reasons have been given[9] why mathematics should be taught in the schools:

1. *Practical reason.* Mathematics is taught for its ordinary practical value to everyone, because it is useful in the direct sense that knowledge is useful just as it is in the other school subjects. For ex-

[8] Jourdain, Philip E. *The Nature of Mathematics*, T. Nelson and Sons, Ltd., London, 1919, pp. 16–17. See also Menger, Karl and Others of the Department of Mathematics, "What Mathematics Is Really Like," Illinois Institute of Technology, Chicago, Ill. A Round Table Discussion on Radio Station WBIK, April 30, 1952.

[9] *The Reorganization of Mathematics in Secondary Education*, A Report by The National Committee on Mathematical Requirements under the auspices of the Mathematical Association of America, Inc., 1923, pp. 2–10.

ample, few people can get along without knowing the fundamental ideas of elementary arithmetic. This reason for teaching mathematics may be and often is overdone. Nobody ever liked a subject because he was told he was going to use it. Although the practical value of mathematics may appeal to certain type of minds, it is clear that in algebra, for example, most of the students like the subject because it is abstract rather than concrete. Moreover, there is a difference between the needs of the student who continues to study mathematics beyond the junior high school period and the one who does not.

Mathematics beyond doubt has what has often been called a "bread and butter" value, but, if we are honest in our thinking, we must of course admit that this value, in particular, has often been overrated. It does have a certain "bread and butter" value because the routine movements in daily life demand a certain knowledge of mathematics if we are to make proper adjustments and progress. The value of the subject to the student lies:

a. in his ability to get a good working knowledge of the fundamentals
b. in his securing speed and accuracy in working with these fundamentals
c. in his developing the power to apply properly these processes to the problems of his daily life.

Two aspects of mathematical truths. As Nunn has so well said:

"Mathematical truths always have two sides or aspects. With the one they face and have contact with the world of outer realities lying in time and space. With the other they face and have relations with one another. Thus the fact that equiangular triangles have proportional sides enables me to determine by drawing or by calculation the height of an unscalable mountain peak twenty miles away. This is the first or outer aspect of that particular mathematical truth. On the other hand, I can deduce the truth itself with complete certainty from the assumed properties of congruent triangles. This is its second or inner aspect. The history of mathematics is a tale of ever-widening development on both these sides. From its dim beginnings by the Euphrates and the Nile mathematics has been on the one hand a means by which man has constantly increased his understanding of his environment and his power of manipulating it, and on the other hand a body of pure ideas, slowly growing and consolidating into a noble rational structure. Progress has brought about, and, indeed, has required division of labour. A Lagrange or a Clerk Maxwell is chiefly concerned to enlarge the outer dominion of mathematics over matter; a Gauss or a Cantor seeks rather to perfect and extend the

inner realm of order among mathematical ideas themselves. But these different currents of progress must not be thought of as independent streams. One never has existed and probably never will exist apart from the other. The view that they represent wholly distinct forms of intellectual activity is partial, unhistorical, and unphilosophical. A more serious charge against it is that it has produced an infinite amount of harm in the teaching of mathematics.

"Our purpose in teaching mathematics in school should be to enable the pupil to realize, at least in an elementary way, this two-fold significance of mathematical progress. A person, to be really 'educated,' should have been taught the importance of mathematics as an instrument of material conquests and of social organization, and should be able to appreciate the value and significance of an ordered system of mathematical ideas. There is no need to add that mathematical instruction should also aim at 'disciplining his mind' or giving him 'mental training.' So far as the ideals intended by these phrases are sound they are comprehended in the wider purpose already stated. Nor should we add a clause to safeguard the interests of those who are to enter the mathematical professions. The treatment of the subject prescribed by our principle is precisely the one which best supplies their special needs."[10]

How can we plan courses in mathematics so that we may realize most fully such an objective? In the first place, it seems to me that we should not plan separately for the two aspects, the practical and the theoretical, in the curriculum. Let us therefore try to choose hypothetically as the most desirable and important that theoretical content which is at the same time the content which arises naturally out of the student's attempts to apply his mathematical ideas and methods to practical ends in his daily life. And by "practical" I do not imply the narrow use of that term which is so often misleading.

It is evident that any attempt to discuss the practical value of the subject must force us to define what we mean by "practical." A better understanding of the word may bring us to closer agreement. The view that a thing is practical only when it can be made to serve one in earning his livelihood expresses a narrow or at least a restricted use of the term. There is a broader meaning that the word may assume: namely, that a thing is practical if it helps one to develop certain ideals of procedure in his mental growth or certain specific habits of action or thinking. This is a cultural, perhaps, but is none the less practical and may be one reason why pre-legal and pre-medical work involves training in mathematics beyond the elementary field.

If we can have agreement on this last point, then we are compelled

[10] Nunn, T. P. *The Teaching of Algebra* (Including Trigonometry), Longmans, Green and Company, London, 1927, pp. 16–17.

to select as a basis for theoretical discussion those topics in mathematics in which the practical value of the content material is most clearly represented. This is not an easy task because it is not always easy to get general agreement as to what things are practical. Moreover, it is well to remember that in actual classroom practice we should not only try to conserve the things which are certain to be practical or even contingently so, but to eliminate from the course such material as is impractical, if not impossible, or obsolete. Such reorganization alone, if honestly carried out years ago by teachers of mathematics, would have made the lives of many children and most of their teachers much happier as well as more valuable.

We teach mathematics because of its general usefulness and its contingent practical value. Note how this differs from the statement made above. Take the aviator's use of mathematics, for example, and you can see what this means. "Practical matters of mathematics," said Nunn, "are not pettifogging details." This reason is the chief one with some of our greatest teachers like Nunn who go out in the busy world, take a situation and dig out of it the important mathematical principle to be taught and learned. The common way of studying Archimedes' Principle by learning it as a principle of fluids or by introducing it in finding the specific gravity of a body is a pedagogical trick. Nunn took his students either actually or in imagination down to the docks and introduced them to the whole problem of the "flotation of ships." Or perhaps he showed them how an aviator or navigator finds his way across the sea. A Lindbergh would never learn trigonometry first and then study aviation. In other words, the skillful teacher who makes utility his chief reason for teaching mathemtaics will take his students where he finds them, secure their interest or perhaps discover it, and then push out to bigger and more fundamental ideas. Neither the engineer nor the scientist could make any headway without a knowledge of mathematics beyond the elementary stage.

There are those who claim that we cannot justify mathematics as a part of the training of every American citizen on any such narrow aim as the utilitarian, but until we have some surer way of determining who can profit most from the practical value of mathematics, using the term "practical" in the broad sense, we shall have to observe a margin of safety in building the curriculum and keep in mind the real uses of the various parts of the subject. We should bear in mind, however, that it is foolish to expect many outside our own field to concur in the practical value for many students.

Important applications of mathematics. Now what are some of the most important applications of mathematics? We may pass over such obvious values as those for the engineer, which few would debate,

and consider some of the less familiar, or, as Hotelling put it, "Little Known" applications of mathematics.[11] What he said is very helpful.

2. *Cultural reason.* In spite of all that I have said it still remains that for a large number of people the most important function of mathematics lies not in its use as an instrument, but in its cultural value. The Commission on Post-War Plans said:

"It wouldn't be fair to you if we ended this discussion of mathematics for personal use without mentioning *enjoyment* and *cultural* values. There is much more in the study of mathematics than the vocational value. Throughout the centuries there have been many persons who have enjoyed mathematics for its own sake. There is a precious cultural value that comes to those who learn to appreciate the contribution of mathematics to civilization—to the progress of man. You are entitled to know (1) that few students if any who are competent in mathematics have ever regretted time spent in learning the subject, (2) that mathematics is an easy subject if well taught and the structure is built carefully step by step, and (3) that there are few subjects which students like better than mathematics, provided it is well taught. So, if you enjoy mathematics, take no thought of the vocational uses in the tomorrow—sufficient for this day is the *good* thereof."[12]

Like literature, history, philosophy, art, music, and the other great branches of learning, mathematics stands for a great movement in the evolution of the human spirit and for that reason must have a place in the education of every American citizen. This reason is given by some as the strongest of all—the one that will still hold good when the other traditional reasons have broken down.[13] There seems to be quite general agreement among mathematics teachers that the main function of the study of mathematics is that it develops the power to do accurate and independent thinking; perfection of course to be more nearly attained as the training in mathematics advances.

3. *Disciplinary reason.* Last and least, because we are not so sure, now, mathematics has been and still is taught because of its disciplinary value. The psychologists have forced the mathematicians to lessen their disciplinary claims, but the former have also had to modify their own statements in regard to the theory under discussion. They have learned to solve some of their own problems by using mathematics. We still think that the theory holds good, but in another way from the traditional point of view of overzealous mathe-

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[11] Hotelling, Harold. "Some Little Known Applications of Mathematics," *The Mathematics Teacher*, April 1936, 29: 157–169.

[12] "The Second Report of the Commission on Post-War Plans," *The Mathematics Teacher*, May, 1945, 38: 195–221.

[13] Kempner, Aubrey J. "The Cultural Value of Mathematics," *The Mathematics Teacher*, March, 1929, 22: 127–151.

maticisms.[14] That is, today, we ourselves admit that the theory has been overworked. Mathematics may discipline one in certain related things, but not in others. Moreover, if we want transfer to take place, we must know what transfer we wish and the best way to secure it.

The theory that the study of mathematics trains the mind was so universally believed in the earlier colonial days in this country that almost every young man preparing for a profession felt it necessary to take a certain amount of mathematics in order that he might better train himself to do his other college and university work. As a matter of fact, however, the college in the earlier days did not offer any more advanced courses in mathematics than some of the high schools in this country are offering today.

We have long since realized that it is not necessary for the student in his study of mathematics to go through all the stages of development which it was necessary for the race to pursue in order that he may have a proper understanding of the subject. Many of us have been privileged to take short cuts in the mathematical program which were absolutely impossible for the race to take in its pioneer work with the subject.

From Thales' time, when a large part of the mathematical work was experimental in nature, the development of the subject has been rapid and at times phenomenal. Even in the days of Pythagoras his school of philosophers had begun to develop the theoretical side of the subject, and since that time the theoretical side has perhaps received the most emphasis.

[14] Orata, Pedro. "Transfer of Training and Educational Pseudo-Science," *The Mathematics Teacher*, May, 1935, **28**: 265–289.

Betz, William. "The Transfer of Training with Particular Reference to Geometry," Fifth Yearbook, National Council of Teachers of Mathematics, *The Teaching of Geometry*, 1930, pp. 149–198.

Jablonower, Joseph. "Opportunities for Transfer Making in Elementary Mathematics," *The Mathematics Teacher*, May, 1928.

Hamley, H. R. "The Transfer of Training," Appendix 5, *Secondary Education with Special Reference to Grammar Schools and Technical High Schools*, His Majesty's Stationery Office, London, 1939.

(*Continued in May*)

SCIENCE FACILITIES FOR SECONDARY SCHOOLS

This publication has been prepared to give help in planning space and other instructional facilities for science in secondary schools. The stress is on general principles that govern the selection and arrangement of facilities. These principles are discussed in relation to the needs of secondary school pupils, especially pupils in small high schools. There are numerous photographs and floor plans. A check-list and an extensive bibliography are included.

"Science Facilities for Secondary Schools." By Philip G. Johnson and a committee of the National Science Teachers Association. Office of Education Miscellany No. 17, 38 pages. 1952. For sale by the Superintendent of Documents U. S. Government Printing Office, Washington 25, D. C. 25 cents.

ANTICIPATIONS REGARDING COMMUNICATION BETWEEN MEN

JULIUS SUMNER MILLER
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Ideas are difficult to come upon. It appears, indeed, to be extremely difficult to think of anything *new*. There is nothing *new* under the Sun. All the rivers run into the Sea and yet the Sea is not full! Yet new ideas and new things are constantly appearing. The human brain is indeed a fertile field. And having a new idea courts reasonable danger. Some men have lost their heads thereby! New ideas are often frowned upon; their authors held in the illest repute. In my own thinking the word *impossible* is no longer safe. I believe Napoleon said the word was not in *his* vocabulary. He made a mistake, of course, but men who do *nothing* make *no* mistakes! It is like the adage: if you wish anything done ask a busy man to do it, the other kind have no time. With this preamble then, I come to a matter on which I have reflected for some time.

Within the year an essay appeared in a respectable periodical, written by a blind doctor of medicine. He reported a small accomplishment of his which I quote: "One minor accomplishment has interested me a good deal. I am somehow able to detect the proximity of a wall when I get within two or three feet of it. The most obvious explanation lies in the variation of reflected sound. Yet I have on occasion been able to make such identification in the absence of sources of such sound." This last line is what I point to explicitly. It is common knowledge that the blind detect the proximity of obstacles by acoustical reflections—by echoes. This is why a blind man taps his cane as he walks. It is not too difficult to acquire this skill, and it constitutes a good experiment for those who still are blessed with their full sight. But what shall we say about the ability to detect an obstacle *without* sound reflection?

For some years I have had an interest in the electric phenomena associated with the thinking process. It is fairly well established that an electromagnetic field circumscribes the active brain, and that this field suffers variations in its properties (intensity, amplitude, frequency, etc.) with changes in "thinking." No less a figure than Albert Einstein has participated in this inquiry. I have long felt that we will one day utilize this electric field for communication between persons, whatever the separation. It will be analogous to "tuning in." *A* will send out a wave which will be received by *B*. This is related to the idea of extrasensory perception, as the reader will recognize, but I feel that the ideas in this region of intellectual endeavor can be sensibly extended.

In the case of the doctor's report it is clear that *sound* waves can be ruled out. There need be no sound. I suggest that it is the reflection of an electric wave from his brain—in the region of the spectrum not yet explored! I feel confident on this point since the phenomenon has twice been reported to me by blind persons.

Two last remarks: I quite realize the *complexion* which this idea possesses. It sounds like pure quackery. But this is the danger which new ideas court!! It would be interesting to ask blind people to watch for this. If we had further evidence of its existence the matter might well merit some inquiry at the highest level.

Plastic cements, formerly available in bulk, now can be obtained by the homeowner in small quantities. The cements actually form a series, each cement working best on certain specific types of plastics. One cement in the series will join plastics to glass, wood and metal without heat, pressure or special surface preparations.

CAN A SINGLE COURSE IN THE BIOLOGICAL SCIENCES FILL THE DUAL OBJECTIVES OF GENERAL EDUCATION AND TRAINING OF FUTURE SPECIALISTS?*

CHARLOTTE L. GRANT
Oak Park and River Forest High School, Oak Park, Ill.

Statistics have shown that the greatest exodus, about 40%, takes place from high school at the tenth grade level. While most of these are lower ability students, nearly one-fifth are top quarter students. Some of these leave because of financial conditions and unsatisfactory situations in the home, but others leave, unfortunately, because the curriculum and instruction of the school do not satisfactorily meet the needs and interests of today's youth, and do not offer a sufficient challenge to develop and explore abilities and aptitudes.

According to the best authorities about one-fifth of America's top quarter students do not finish high school, a little less than two-fifths do finish high school but do not continue on to college, and a little more than two-fifths do finish high school and proceed on to college. By proper guidance and financing it is believed that this group may be increased to around 70% or approximately one-third above what it is at present.

Perhaps we should consider the prime purpose of a school at this point, before proceeding to curricula. Outstanding educators tell us that the purpose of a school is to provide experiences so that the needs of youth and the requirements of society may be met effectively. The means of accomplishing this end constitute the basic task of curriculum makers.

To the above statement may be added a recent argument in favor of teaching science taken from the Fifty-first Yearbook of the National Society for the Study of Education: "Science instruction should prepare a student to meet his needs in living a happy and purposeful life."

If we are to meet the needs of our high school youth in science, particularly the biological sciences, what kinds of aims and objectives, curricula, and techniques of instruction should we set up?

A recent U. S. Office of Education publication indicates that from a study of 786 schools, 21.65% of all students enrolled in these schools were taking general biology. Forty-one per cent of the schools required biology; 53.8% offered it on an elective basis. Further, in the various curricula, 41.1% of the college-preparatory curricula re-

* Presented to the Junior College Group of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, Chicago November 29, 1952.

quired biology, 36.6% of the vocational curricula indicated biology as a requirement, and 32.8% of the general education curricula placed biology as a required course.

The U. S. Office of Education bulletin further points out that biology is the only science course offered which has shown consistent increases in enrollment in keeping with the general increase in high school enrollments. Other science courses have shown either marked decreases in enrollment or slight and intermittent increases which are not proportional to the gains in total enrollment.

If biology holds such an important place in high school education what should be the aims and objectives of such a course? The following list is compiled from many sources and from the best authorities in science education.

1. To meet the needs and interests of students.
2. To help students acquire knowledge with an understanding of relationships, and application to every day living.
3. To build a vocabulary, both scientific and non-technical.
4. To develop skills and techniques in the classroom and laboratory.
5. To discover aptitudes and abilities in students and direct these into useful channels.
6. To develop critical thinking, interpretation of data and sound evaluation.
7. To develop desirable attitudes and appreciations.
8. To teach an understanding of people and ways of working together.
9. To help students formulate a philosophy of life with a wholesome and workable set of values.
10. To aid students in bringing about desirable modifications of overt behavior leading to good citizenship.

Perhaps as you consider these objectives you will exclaim "Many of these are common to other areas of the curriculum, too, they are not limited to science alone!" True. But most of us will agree that common needs have been neglected more frequently than specialized needs. However, we will also agree, that we have only begun to explore the steps involved in challenging as completely as possible the specialized interests of boys and girls.

Let us now examine the basic organization of general biology as taught in the high school, primarily at the tenth grade level. Many schools today are developing such courses around principles related to biology. Some of these are:

1. Kinds of living things
2. Organization of living things
3. Energy, matter and life
4. Health, disease and nutrition
5. Conservation
6. Heredity, genetics and eugenics
7. Embryonic development
8. Ecological relationships

9. Geographical distribution of living things.

Fewer schools are using a course organization consisting of a specialized treatment of botany and zoology; or at the other extreme, of broad topics which cut across the entire curriculum, and may be said to be important to daily living at any level of instruction.

A basic textbook, or texts, seems to be preferred in most schools. This is supplemented by other books and pamphlets, and a variety of related activities.

Procedures for teaching biology should include some form of laboratory. The U. S. Office of Education bulletin indicates that this is true in about 97 per cent of the schools studied. Some laboratories are regularly scheduled, others are an integrated laboratory-recitation type, and still other schools prefer a flexible laboratory schedule. There seems to be a trend in the latter direction. Small group experiments and individual laboratory work seem to provide more active instruction and to take preference over teacher-demonstration and pupil-observation only. Pupil-teacher planned experiments and class activities are far more desirable and popular than experiments planned by the teacher alone or taken entirely from a workbook or manual. Recent studies would also confirm this statement.

Supplementary activities for a general biology course are many and varied, depending upon the size of the school, its location, and its teaching personnel. Some activities may center about a greenhouse, a nature trail, a garden, a farm or a forest preserve; others about a museum, a camp, club activities, or various community resources.

Supplementary aids in the school may take the form of charts, living and preserved specimens, microscopes, slides, posters and pictures, film-strips, motion pictures, microprojectors, models, recordings, and library books and pamphlets.

While we are attempting to fulfill the aims and objectives of general biology instruction, what can we do to meet the specialized interests of our gifted or talented student in biology?

We can incorporate into the curriculum, especially in the larger schools, additional biological courses such as agriculture, conservation, botany, zoology, health and physiology.

We can offer motivating and challenging activities to the talented student such as planning science assemblies, taking part in science contests sponsored by special agencies, tutoring slower students, acting as assistants in setting up laboratory experiments and projects, devising tests and vocabulary lists for drill in class, helping in part-time jobs in industry, where some science training is required, and finally participating in Junior Academies of Science, the Westing-

house Science Talent Search and the recently established Future Scientists of America Foundation.

We can give guidance to the gifted student through ability and aptitude testing, through acceleration in courses where such seems feasible, through ability grouping within certain courses, through career conferences, and through group and/or individual counseling.

These are only a few examples of the many challenging activities and experiences which may be provided for the young person with specialized interests in science, but to do so a school should have well-trained teachers, a sympathetic and interested administrative staff, adequate facilities, and a community of parents which believes in and is willing to sponsor the school activities.

It is said that at least 50% of the superior students need guidance and assistance, both in an academic and emotional sense. High I.Q. and high academic achievement play only a partial role in the behavior of the gifted. The psychology of the home and the best pedagogy of the school are important factors in the total behavior of the students.

Future America will need young people who have technical and scientific competence and who will have been trained to understand people and to work with them. As teachers we are faced with a tremendous task though a challenging one. We must keep abreast of new research, better materials and more adequate methods and skills in the scientific and technical world. We must develop courses which challenge students to deeper thinking and greater activity. We must provide adequate materials for reading, research and motivation, or indicate resources for such motivation. We should respect their attitudes, criticisms and evaluations, for much is to be gained from youthful co-operation, and many courses need the enrichment of young ideas. And above all we should be democratic enough to permit differentiated student activities in class so that the course meets their needs and explore their interests, for no two students understand, interpret and react in exactly the same manner. To reach the goals of science education, and to meet the demands placed upon the science educator seem a large order but there is no other profession which offers more satisfying experiences and more worthwhile achievement than the directing and casting of youthful futures and careers.

Plastic globe with a map of the world printed on it in five colors is helpful to children studying geography. Blown up like a balloon, the 16-inch sphere is made of a rugged vinyl plastic that withstands wear and tear if the globe also is used as a beach ball or if it is bounced like a basketball.

HIGHLIGHTS FROM THE INTERNATIONAL GEOGRAPHICAL CONGRESS*

MAMIE L. ANDERZHON
William Beye School, Oak Park, Ill.

It was a stimulating experience for geographers and those interested in the contribution geography makes to science to attend the International Geographers Congress in Washington D. C. during August 1952.

Just prior to the Congress the American Geographical Society, the Association of American Geographers, the National Council of Geography Teachers, and the Pan-American Consultants on Geography held annual meetings. Other special features included the New England and Industrial Cities Excursions, special programs arranged by the National Geographical Society, a Blue Ridge Mountain Trip, opportunities to see the prdouction of government maps, and trips to points of interest in and about Washington D. C. in addition to social events.

This meeting of the Geographical Congress was the first held in the United States since 1904. To watch the delegates register and gather for the sessions was an experience in itself. There were 1500 delegates and members from 50 countries. All of the general sessions were provided with simultaneous translations into English, Spanish, and French.

For everybody there was the universal language found in the brilliant map display from many countries. The extensive and comprehensive map exhibit received considerable attention and study. Maps being the tool of the geographer there were many exchanges of ideas and techniques showing arrangements and distributions of all mapable features. Many of the maps were dynamic in character.

WHAT THEY TALKED ABOUT

The research papers from all areas of geographical thought included inventory, classification, and mapping of resources, physical and human features and historical sequence.

The session on the teaching of geography was well balanced with speakers representing both the physical science and the social science fields. All grade levels were represented by research reports. At the elementary level the social aspects of people, place, and work were well outlined in curriculum programs. At the secondary level greater emphasis was placed upon physical geography.

* Presented at the Geography Section of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, November 28, 1952.

Other sessions which often carried through for several periods were concerned with densely peopled areas, the reports and discussion on many aspects of Conservation, Urban and Rural Settlements, Demography and Cultural Geography, and the reports from Commissions on Industrial Ports, Regional Planning, and Resources in Agriculture and Industry.

The Symposium on World Food Supply had wide participation. Dr. Cressey, President of the IGU addressed the Congress on Land for 2.4 Billion Neighbors. This address summarized many of the statistics related to the world food problems.

Frontiers where it is too dry were considered in research reports dealing with Arid Regions and Hydrography. Alpine Studies gave us reports on what is being done on mountain slopes that have been considered too high from much habitation. Of course considerable attention was given to reports from areas that are too cold for habitation when considered from the point of view of middle latitude dwellers. The Honorable Hans Weson Ahlmann's banquet address on Glacier Variations and Climatic Fluctuations (an Isaiah Bowman Memorial Lecture) left no doubt but that physical environments and phenomena in every part of the earth can become significant in the lives of densely peopled areas. Other sessions included research on Geomorphology, Climatology, Cartography, Biogeography, Medical Geography, and Trade and Transportation.

Commissions Engaged in Research for the Coming Years

The following International Geographical Union commissions for research were named at the close of the General Assembly:

Medical Geography
Periglacial Morphology
Inventory on World Land Use
Arid Zone
Karst Phenomena
Geography in Schools
Erosion Surfaces Around the Atlantic
Library Classification of Geographical Books and Maps
Evolution of Slopes
Coastal Sedimentation
Special Committee on the International Date Line
Special Committee on Conversion Tables
Bibliography on Ancient Maps

Many geographers from the United States are serving on these commissions.

The theme and international significance of the meetings were

well expressed by Dr. Cemal Arif Alagoz, Ankara University, Turkey when he said, "Scientific men and women from more than 50 nations worked together in harmony, grew to understand each other and exchange ideas. Above all, we came to like and respect each other, and to sympathize with our neighbors' problems. If ever there should be disputes between our prespective countries every one of us can be trusted to raise a strong voice for peace in his own land." Could a better statement of the function of modern geography be made? Not only has the personal life of each one of us who attended this Congress been enriched for having worked together in this Congress with geographers from many parts of the world but our shared experiences continue to be shared with those with whom we work as each one of us returned to our respective homes around the world.

The Congress concluded with two trips, a Transcontinental Excursion and a Southern Tour for those who wished to visit more of the United States.

In 1956 the Congress will meet in Rio de Janeiro, Brazil. The colorful L. Dudley Stamp, geographer in the London School of Economics was elected president.

TEACHING THE CALENDAR

A novel and strikingly different method of teaching eight, nine and ten year old youngsters the story of THE CALENDAR has been created by the Audio-Visual Division of Popular Science Publishing Co., 353-4th Ave., New York City. This all-new full-color visual teaching aid consists of six titles.

Here is a really basic teaching aid that helps educators SHOW and TELL youngsters in grades 3 to 5 the wonders and meaning of days, weeks, months, seasons and years. For use in Social Studies, THE CALENDAR is the work of eminent educators and technicians. Every frame was created from special artwork and photographs prepared for this fine series.

The six encompassing titles are: "How a Day Passes," "A Busy Week," "The Month," "The Year," "Spring and Summer," and "Autumn and Winter." Each of these full-color frames helps teachers get across often difficult-to-teach facts about seasonal changes in life—how such changes affect our activities, family life, school life, playtime, farming, industry, clothing, business, and all other phases of life around the country.

Teachers and pupils will be pleased with the use of boys and girls of pupils' ages to illustrate points being made. Pupils see how youngsters just like themselves are affected by changes in THE CALENDAR. Teachers will be delighted to screen this full-color, true-to-life series again and again, because it will save them so many work hours, and instill in children the true meaning of how every life actually revolves around the Calendar.

There is a complete set of six fully-illustrated Teaching Guides included in this full-color filmstrip series at no extra charge. These Guides are invaluable aids to suggesting how lessons can be planned and conducted. Also included in this unit is a hard-cover, permanent file-type box container which will protect series against years and years of use in class-room lessons. Price for complete unit is only $31.50.

Further information on THE CALENDAR is available at your local audio-visual dealer, or the Audio-Visual Division of Popular Science Publishing Co.

GRAINS OF SAND AND DROPS OF WATER HELP MAKE NUMBERS MEANINGFUL

MELVIN O. WEDUL
State Teachers College, Winona, Minnesota

Six trillion grains of sand make how big a sand pile? This is a question few children or adults can answer with any degree of accuracy. The question may also be asked, "What difference does it make anyway?"

Children at an early age seem to be fascinated by large numbers. Preschool youngsters have been overheard speaking glibly of millions and octillions, but even at the junior high level most pupils have a very vague concept of the real meaning of large numbers. Pupils in the upper elementary and junior high school are using large numbers in various phases of their work in connection with the national debt, air mile distances, astronomy, geology, mathematics, and other course work. Perhaps of no less importance to these youngsters are the programs they see and hear such as "Space Cadet," "Space Patrol," and "Captain Video."

WHAT IS A LIGHT YEAR?

The term "light year" may be taken as an example of a term which seventh graders can define quite readily. They can easily give the speed of light and the distance it travels in a year. They can write out the numbers and perform arithmetic computations with them. They can give distances to the sun, moon, and nearest stars; but do they have a real appreciation of the magnitudes involved?

In a discussion of the universe and units of measurement in space this question was presented to a seventh grade science class: What is there in our surroundings which we have in quantities equal to the number of miles in a light year? Several things were named as possibilities such as bricks in a building, hair on a person's head, kernels of wheat, drops of water, leaves on a tree, and grains of sand. For convenience in discussion a light year was rounded off to six trillion miles. Written estimates were made by all the pupils to indicate the amounts of each material six trillion units would make. In referring to sand the estimates ran from a thimble full to a washtub full. The estimates made by some adult groups have not been much more accurate.

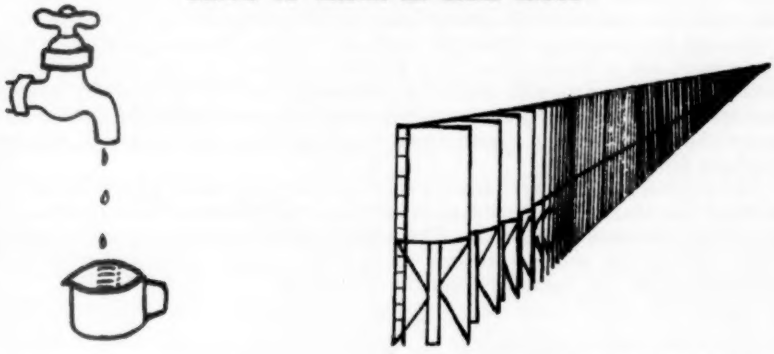
HOW CAN THE ESTIMATE BE TESTED?

Since methods had to be devised to reach somewhat accurate conclusions about the amounts involved, the group divided into

committees each with a material to use in solving the problem. Each committee formulated its question and planned the procedure for counting a small unit of the material and then calculating the amount in larger familiar units. The group working with grains of sand used a balance and a gallon pail. A gram of sand was weighed and divided among all class members for counting of the grains. By this procedure each member had only three to six hundred grains. When the totals were made, the committee could proceed to calculate the number of gallons occupied by six trillion grains of sand. The committee finally announced this conclusion: If fifty-gallon drums were used on trucks with ten drums on each truck, it would take three hundred trucks to haul six trillion grains of sand.

The committee choosing water as a medium used a dripping faucet and a measuring cup to get the number of drops in a gallon. They decided to use the city water tank as a unit in their final expression.

DROPS OF WATER IN TANK UNITS



Six Trillion Drops   Three Hundred Water Tanks

The city water tank holds five hundred thousand gallons of water, but they concluded that it would take about three hundred water tanks to hold six trillion drops of water. An interesting sideline product was the calculation of the hundreds of years this faucet would have to keep dripping to produce the required amount of water.

Of What Significance Is this Procedure?

Each committee had to devise the most accurate means available for making the check on the estimates. None of the results can be considered significant in a scientific sense and have no particular value as such, but the value must be found in the means used in deriving the results.

After carrying out the described procedure with several groups, the

writer has concluded that the procedure is valuable for the following reasons:

1. The pupils enjoy it.
2. The required materials are readily available.
3. It is problem solving in a concrete way.
4. It provides practice in the scientific method.
5. Practice in estimating is provided.
6. The pupils appear to get a greater appreciation of large numbers.
7. The pupils derive satisfaction from working out their own answers to a question which most adults around them cannot answer.

FILM STUDY GUIDES FOR PUPIL USE

Users of educational films can now run off mimeographed study guides to give to their pupils before showing the film, if they have the stencils being produced by College Entrance Book Co., 104 Fifth Ave., New York 11, N. Y. Called CEBCO FILMGUIDES, each of the stencils is based on a specific film, and provides motivation and preview material, observation and discussion questions, diagrams and picture studies, and followup activities.

Stencils for more than 20 widely used school films are now ready, and a great many more are in preparation. It is hoped eventually to include all films which have achieved a reasonable degree of popularity and for which study guides are appropriate. The guides are prepared in cooperation with the film producers and under the supervision of an advisory board of educators skilled in the use of teaching films.

The stencils have been cut from special printing dies, using type faces especially selected for their legibility in mimeograph reproduction. The stencils can be stored and re-used indefinitely. The price is $2.00 per stencil, including a file folder for storage, and a teacher's proof copy, answer sheet and manual. Full information can be obtained from the publisher.

NEW WAY OF PACKING LEMONS

California citrus growers can lop $6,000,000 a year off their costs of packing lemons by adopting a revolutionary new packing technique developed by a University of California agricultural researcher.

Dr. Roy J. Smith, associate professor of agricultural economics, who developed the new technique, estimates the new method will save lemon packing houses about 72 cents a standard box since it cuts down packing costs as much as 80%. Such a saving would easily exceed the $6,000,000 mark since California growers ship an estimated 9,000,000 boxes of lemons each year.

In contrast to the conventional method of packing lemons, in which each lemon is sized, wrapped in paper and placed in wooden crates by hand, the new process allows the lemons to be literally "poured" unwrapped into chemically-treated cardboard cartons which are half the size of old-type wooden crates. Before the carton is sealed by a special machine, the fruit is shaken into a solid full pack by placing the box on an electric vibrator.

"The key to packing lemons in bulk," said Dr. Smith, "was the development by a Florida company of a fungistatic material with which the inside of the carton is laminated. This material stabilizes fungi growth and sets up a vapor pressure which prevents spoiled fruit from contaminating others."

Dr. Smith worked with the Citrus Industry Research Association and several commercial firms.

HIGH SCHOOL PHYSICS AND MATHEMATICS AS APPLIED TO AIRCRAFT ENGINE MECHANICS*

ALVIN HARRISON
Dunbar Trade School, Chicago, Ill.

INTRODUCTION

Mathematics and physics, as commonly taught in our high schools, give many of our youngsters a kind of mental and emotional indigestion. Too frequently do we leave the pupil's knowledge, understanding and appreciation of the rich practicality of these subjects to chance. We explain our heads off trying to make clear certain principles of heat, magnetism and electricity, but large segments of our pupils find our explanations either uninteresting or meaningless. We earnestly teach the processes of algebra, but many youngsters find the subject to be a mad, unscrambled mass of letters and numbers. We gain dubious satisfaction from the small minority who comprehend our subject matter while writing off as mathematically and scientifically unworthy those who do not. We assure ourselves that these uncomprehending pupils are just not mathematically minded or that their intelligence quotients are so low as to render understanding of science and mathematics impossible. We do this in spite of what we know about the serious challenges being hurled at the validity of our intelligence tests in recent years and the serious studies being undertaken to construct "culture free" tests—tests free of the bias of social class. Some of us dismiss the large number who have difficulty with our subjects as being those whose egos have been wounded by failing experiences with arithmetic as taught in the elementary school. We contend that the very mention of anything numerical causes such children to raise a protective emotional bloc that thwarts all reason, intelligence and competence in dealing with science and mathematics.

Some educators are today advocating one year of high school mathematics for most children. Moreover, for these children they are asking a watered-down version of physics—non-mathematical physics. I seriously wonder whether this is even partially the answer to the problem of nearly fifty per cent of our high school youngsters' dropping out before graduation.

I believe that the success of our educational exertions and, indeed, the ultimate success of American democracy are going to require our schools to do a better than fifty per cent job of holding students. And surely a lack of success with mathematics and the natural sciences is

* Read before the General Science Section of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, Chicago, November 28, 1952.

going to have to be reduced as a factor in increasing drop-outs. Too frequently today adults in all walks of life point to the difficulty that they experienced with mathematics. Many of you have probably heard and seen youngsters being interviewed on television who said their most difficult subject was arithmetic. Immediately the announcer follows with the statement that it was also his most difficult subject. Such statements do not do our subjects' public relations any good. Moreover, the feeling widely held that mathematics and the natural sciences are the domain of the specialist and are not of worth to the average intelligent citizen does not increase the popularity of these subjects.

You and I must take care lest a wave of educational softness, resulting from popular misunderstanding and from our own teaching practices, should wash our subjects from the secondary school curriculum. While we should appreciate the pyschological undergirding of some of the newer tendencies in education, we must at the same time insure, by the most enlightened teaching methods, that the attacks being made on our subjects are not the result of our own failings. We must insure that generations of students do not leave our high schools convinced that our subjects are the most difficult and the least practical in the curriculum. This, it seems to me, is not too difficult in the education of young people for living in a highly industrial society.

The difficulties encountered in the teaching of mathematics and physics are too well known to you for me to dwell on them here. However, if I were asked what I consider to be our chief difficulty, I should answer that it is the unrelatedness of our subject matter to life and to pupils' experiences and motives. To us x and y are symbolic of a variety of concrete things; T_1 and T_2 are initial and new temperatures respectively. To many youngsters, in spite of our many words of explanation, they are merely letters which some of us are mad enough to attempt to manipulate mathematically. Having been reared and trained as most teachers are, we see the significance of our teaching and we cannot understand how it is that some experiential variable imparts for youngsters an entirely different meaning to our subject matter from that which we get. Our problem may be experiential incompatibility. Indeed, we simply may not perceive enough in the experience of many children to tie our symbols and concepts to in order to promote learning. There is an icy unrelatedness surrounding much of our work that leaves many pupils unmoved.

Take, for example, the demonstration of an electromagnet. Most of us have contrived some means of demonstrating this phenomenon. But I ask you if the relatedness, the practical application and worthiness of this phenomenon would not be more clearly demonstrated to

our pupils if our contrivance were a starting switch for an automobile? To be sure, most of us tell our pupils of the practical uses of solenoids. But, would it not be better if the starting solenoid itself could be utilized to demonstrate the electromagnet?

Under our C.A.A. mechanic school program in the Chicago Public Schools we are striving to give to important scientific learnings rich practical substantiation and clarification in our shops and classrooms. Through shop experience in which most youngsters are intensely interested we are finding increasing opportunity to relate, use, and stimulate understanding of mathematical and scientific learnings.

In the two computations which follow an attempt will be made briefly to indicate some applications of mathematics and physics to aircraft engine mechanics which we feel to be of use in clarifying SOME principles and facts of those subjects for the average learner.

The Computation of Indicated Horsepower

Indicated horsepower is the power that is developed within the cylinders of an engine; it is the power that is delivered to the piston. It is the formula for computing this horsepower that I want now to consider with you.

Most of you know that aircraft engines, and automobile engines for that matter, go through a series of four strokes to produce one power stroke. We think of these strokes as going like this: The piston moves down on the intake stroke and sucks in a combustible fuel air mixture from the carburetor. Then, the piston moves up and compresses this explosive mixture of fuel and air. When the piston comes near to the end of the compression stroke, the spark plug ignites the fuel-air mixture and it burns generating much heat which greatly tends to expand the confined gases so that they force the piston down on the power stroke. You will recognize here that from Charles' law we could approximate the pressure that is exerted against the piston if we knew the initial temperature and pressure of the compressed combustible gasoline and air mixture and the new temperatures to which the burning gases are raised. After the piston is forced down by expanding gases on the power stroke, the piston moves up to push these burned gases out of an open exhaust valve. This, the fourth stroke, is called the exhaust stroke. It takes two revolutions of the crankshaft to produce these four strokes. They occur over and over again in an operating engine.

You and I are concerned about the power strokes—the working strokes at this time. We want to compute the power being delivered to all of the pistons of an engine. But let us take these pistons one at a time.

Let us suppose that we have one of our cylinders equipped with a pressure gauge that will record the highest pressures developed in the cylinder. From such a device we could approximate the average pressure acting on the piston during the power stroke. Let us call this average pressure P. Sometimes this average is referred to as indicated mean effective pressure. What is the significance of P in the determination of indicated horsepower? If P is 300 pounds per square inch, it means that on each square inch of the piston head—which is a circle—a force of 300 pounds is pushing during the power stroke.

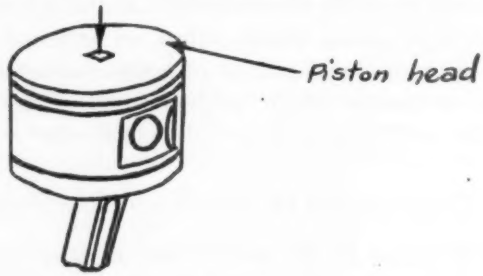


FIG. 1. The piston of an aircraft engine.

It is well and good to know the average pressure that is acting on each square inch of the piston head during the power stroke. But, if we are to find the power acting on the piston we must know the total force acting on the piston during this stroke. How shall we find this? We said the piston head on which this pressure acts is a circle. If we know the cylinder bore or, for all practical purposes, the diameter of the piston head, we can find the area of the piston head in square inches. If D equals the cylinder bore or piston head diameter, we can use the formula

$$A = .7854D^2 \tag{1}$$

to find the area of the piston head. But, this is not the formula for finding the area of a circle to which our pupils are accustomed. Here it is a good thing to ask pupils if it does give the same result as the formula

$$A = 3.1416r^2. \tag{2}$$

When they find it does, then it sometimes proves interesting to have them find how formula (2) is derived from formula (1).

Having computed the area in square inches of the circular piston head and knowing the pressure acting on each square inch of that piston head during the power stroke, we are now in position to conclude that the force acting on the piston head equals

(3) PA (pounds)

where P is the indicated mean effective pressure and A is the area of the piston head in square inches.

The next question with which we are faced is that of determining how much work is done on the piston during the power stroke. We know that work is force acting through a given distance. And the unit of work is the foot-pound. We know the number of pounds of force acting on the piston head, but how far does it act? Well, the distance through which the piston moves in being pushed from top center—its highest point of travel—to bottom center—its lowest point of travel—is called the stroke. It is customarily given in inches. But for our purposes here we want to know the length of the stroke in feet. Thus, if L equals the length of the piston stroke in feet, then for a piston having a 6 inch stroke $L=\frac{1}{2}$. If the stroke is 5 inches, $L=\frac{5}{12}$. It will be clear then that if from (3) we know the force acting on the piston and if we know the number of feet through which this force acts, we can immediately give the work done on one piston in a power stroke as

(4) PLA (foot-pounds).

But an engine has many pistons—one for each cylinder. It will thus be apparent that if N is the number of cylinders in the engine, then the total work done in all cylinders after a power stroke occurs in each of them is given by

(5) $PLAN$ (foot-pounds).

We must now note that in two revolutions of the crankshaft of our conventional automobile and aircraft engines all cylinders fire. For example, a six-cylinder engine will fire or deliver power to all six of its pistons in two revolutions of its crankshaft or in 720 degrees of crankshaft rotation. On such an engine these power strokes are equally spaced and will be 720°/6 or 120 degrees apart. Hence, it will be seen that it takes two crankshaft revolutions—and this is what we refer to in talking about engine r.p.m.—to produce power strokes in all of an engine's cylinders. If an engine crankshaft is going 2000 revolutions per minute, then 1000 power strokes are occurring in each of its cylinders every minute because it takes two crankshaft revolutions to produce one power stroke. If we let K equal the number of power strokes occurring in each cylinder per minute, we can see that at a given engine r.p.m.

(6) $$K=\frac{\text{r.p.m.}}{2}\,.$$

We can see, further, that the work being done on all pistons of an engine in one minute would equal the work done on all engine pistons in one power stroke multiplied by the number of power strokes that each piston is going through per minute. Thus, the total foot-pounds of work being done on the pistons of an engine is represented by the quantity

$$PLANK \text{ (foot-pounds per minute).} \tag{7}$$

Now indicated power is conventionally given in units of horsepower. And, one horsepower is equal to 33,000 foot-pounds of work per minute. Thus the indicated horsepower developed in an engine equals

$$\frac{PLANK}{33{,}000}. \tag{8}$$

THE COMPUTATION OF BRAKE HORSEPOWER

While indicated horsepower is the power developed in the cylinder of an engine, brake horsepower is the part of that power developed that actually results in useful work. For an aircraft engine it is the power that results at the propeller shaft for rotating the propeller. Let us consider the computation of this horsepower by means of a prony brake.

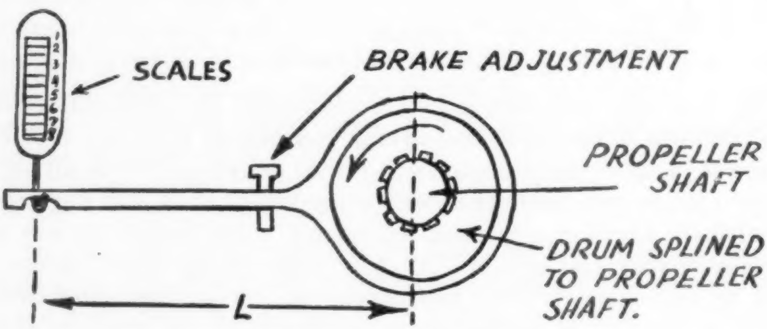


FIG. 2. Prony brake.

The prony brake consists of a means of putting a brake on the propeller shaft that tends to oppose its rotation. If the propeller shaft is rotating in a counter-clockwise direction as is indicated above then a force will be exerted on the arm which pulls down on the scales. It will be understood that the tighter the brake is on the drum that is fixed to rotate with the propeller shaft, the less will be the r.p.m. of the shaft and the greater will be the force exerted on the scales by the arm.

Torque, which is a turning moment, would equal the weight registered by the scales multiplied by the length of the arm. If F equals the weight on the scales in pounds and L equals the length of the arm in feet, then T, torque in pounds-feet, can be determined by the formula

$$T = FL. \tag{9}$$

Now the question arises, how much work is being done by the rotating shaft at a given r.p.m.? Since work is force acting through a certain distance, then the work per revolution accomplished by the rotating crankshaft equals the force registered on the scales multiplied by the distance through which it acts in one revolution. This distance is merely the circumference of a circle of which the length of the prony brake arm is radius. Since the formula for the circumference of a circle is

$$C = 2\pi r, \tag{10}$$

then the work done per revolution by the rotating propeller shaft equals

$$2\pi FL \tag{11}$$

where F is the force and $2\pi L$ is the distance through which it acts in one revolution. Since from formula (9) $T = FL$, then substituting T for FL in (11) we get

$$W_1 \text{ (work per revolution)} = 2\pi T. \tag{12}$$

Now if we know the engine r.p.m., then we can see that the total work done, W_t, is represented by the formula

$$W_t = W_1 \times \text{r.p.m.} \tag{13}$$

Expressing formula (13) in another way we get

$$W_t = 2\pi FL \times \text{r.p.m.} \tag{14}$$

Therefore, the brake horsepower output of the engine, B.H.P., can be represented as follows:

$$\text{B.H.P.} = \frac{2\pi FL \times \text{r.p.m.}}{33{,}000}\,. \tag{15}$$

If $2\pi/33{,}000$ is considered to be a constant K, then B.H.P. $= FL \times$ r.p.m. $\times K$ where $K = 1.904 \times 10^{-4}$.

Expressed differently

$$\text{B.H.P.} = KTR \tag{16}$$

where K is the constant given above, T equals torque in pounds-feet and R is engine r.p.m.

Conclusion

I have sought in the two power formulas derived above to call attention in some small degree to the applications of physics and mathematics to aircraft engine mechanics. You will probably agree that in these computations such matters as force, pressure, work and power take on real, live significance. It is our humble feeling at the Dunbar Trade School that when these concepts are taught in such a practical and operational setting as that which we have attempted to describe in this paper, they take on new significance and meaning. We feel too that some strengthening of mathematical understanding results. We seek to take advantage of what we call the occupational motive as well as of practicality in stimulating mastery of as many scientific and mathematical understandings as possible. I believe we are finding that eyes and minds that are many times blind to principles and concepts enshrouded in academic isolation are opened to these same principles when they are given the substantiation and clarification of some useful, practical, operational setting. For what it is worth I commend this approach to you.

We do not claim that this approach is a cure-all. No single technique can in one thrust obliterate many years' accumulation of mathematical deficiency and the emotional consequences to many children of perennial failure. We do hope some time, through a carefully conducted study, to support the hypothesis expressed in this paper that the practical, operational approach for demonstrating scientific and mathematical principles is superior to the conventional approach as a means of challenging and promoting learning by youngsters of divers levels of ability. Moreover, we propose to support our belief that the motive of productive occupation, which is real and substantial for most youth, strengthens learning even of the principles and facts of conventional mathematics and science curricula.

And now I close this paper by reading to you the foreword from the 1952 *Prospectus*, a yearbook published by the students of the Dunbar Trade School of Chicago. This foreword appeared in the tenth anniversary edition of the yearbook which commemorated a decade of service by the School. I believe this foreword, coming from our students is quite germain to what I have sought to say in this paper.

"Idle minds are the devil's workshop; idle hands are his implements of delinquency and crime. But, productive occupation is the

substance of good citizenship and character. Feelings of uselessness prevent the normal growth of character and conscience. Pupils feel useless when school work is unleavened by reality, when their great native urge to accomplish, to produce, to serve is neglected. Dunbar has rendered a decade of service to Chicago by focusing its attention on this productive urge. It has woven its instruction around the fundamental thread of productive occupation. In so doing it has made Chicago a richer city because of the feelings of security and success it is giving to young Chicagoans and because of the wealth the minds and hands of Dunbarites are preparing to produce for the comfort and well-being of their fellow citizens."

AN EXPANSION OF THE "BRICK WALL" ANALOGY

ROBERT C. MCLEAN, JR.
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Sometimes teachers of courses which are concerned largely with developing an understanding of a closely organized body of knowledge consider themselves, and their students, to be building brick walls. That is, each fact must be laid upon a firm foundation of previously learned facts, and the teacher is beset by a fear that he may not set the earlier facts firmly enough to carry the weight of later developments.

One such teacher was present at an institute of high school mathematics teachers. Although he did teach one course in basic mathematics, he reported that he was a chemistry teacher, and that the problem which he faced, and on which he would like advice, was concerned with the teaching of the concepts of the metric system as the first unit of his chemistry course. He felt that, in spite of all the devices and techniques which he employed, the press of time often forced the class on to the second unit before they had mastered the first.

He was reassured by those present that all teachers were sometimes doubtful about the advisability of leaving one apparently poorly-understood unit, one which appeared basic to much that followed, to go on to new work. In considering this teacher's predicament, one can see that he needs more than reassurances. Although some professor of education might present a more learned treatise, if the initial problem is recognized as innate in the present "brick wall" concept of science and mathematics courses, one brick laid upon another, the solution may be found in recognizing that a teacher is *building* a wall. We should think about the wall in the process of being built rather than as it appears when finished.

When a mason has completed the first course of his wall he does not wait for the mortar to set before building upon it. In fact, he lays the second, third, and all following courses without any concern for those below. The mason, unlike the teacher, is concerned with finishing the wall *before* the mortar has set. Why? Because he wants the wall to be a finished whole, with the mortar and bricks cohesively held together in one wall.

This thought offers the key to the teacher who needs to carry this analogy over into his course. The teacher offers certain discreet facts and processes to the student from which a wall should be built. The teacher presents them in logical order. However, at the end of the term, the teacher does not want the student to have a neatly stacked pile of individual bricks—or a jumbled mass of individual bricks—he wants a solid wall of related ideas. In the process of teaching, as in the process of wall building, the parts need to be set as a whole, or the child is bewildered and the teacher unsuccessful.

Once in a while, let us, as dose the mason, step back from our work and see how the wall is coming along—and let us show our students not only the statistics on the number of bricks laid, but upon the progress of the whole, the wall they are building. Let us not be concerned with a brick or two which appear to be poorly set in the lower levels. As the student begins to see the whole wall, he can recognize the misalignments and, as the mortar should not have set too firmly, he can get them in line, with a minimum effort, and almost no teacher help.

ANNOUNCEMENT

ILLINOIS STATE NORMAL UNIVERSITY

SIXTH ANNUAL SPRING CONFERENCE

ON THE

TEACHING OF ELEMENTARY AND SECONDARY MATHEMATICS

Saturday, April 11, 1953

9:00 A.M.—3:00 P.M.

Theme: Growth Through Mathematics
Principal speakers at morning session:

Elementary: Dr. John R. Clark, Teachers College
Secondary: Frank Allen, Lyons Township High School La Grange, Ill.
Group meetings for both elementary and secondary teachers.
Panel Discussion in afternoon, topic: Evaluating Growth in Mathematics
Dr. Bjarne R. Ullsvik, I.S.N.U., Dr. Clark, Frank Allen

Silverware cleaner is a magnesium alloy stamped into the decorative form of a leaf. Placed in a dishpan with warm water and a good detergent, the leaf removes tarnish in a matter of seconds from any silverware touching it, leaving the silverware gleaming and bright.

ABOUT THE PSYCHOLOGICAL INTERPRETATION OF MATHEMATICAL ERRORS

ELIZABETH HELLY
Walden School, New York, N. Y.

I

The interpretation of errors has been commonplace since Freud. In my work as a mathematics teacher I deal with a special kind of error, which seems to be distant from the emotional part of the personality, and therefore, perhaps, less embarrassing, but which actually provides a vital clue to personality analysis. Some errors, of course, are simply due to fatigue or poor training; these are mainly arithmetic mistakes. But the errors I want to discuss are of a different nature.

We are accustomed usually to diagnose characterological traits through the analysis of reactions to certain non-intellectual situations (Rorschach Tests, etc.). I shall try to show that even in performing a purely intellectual process as mathematics, the personality reveals itself, quite independently of its intelligence level. Below are a few examples of indicative errors; I am sure every teacher can add many more.

II

Jim wrote:

$$5x = 15$$
$$x = \pm 3.$$

I asked him, "why plus or minus." He answered "to play safe." Of course, this is not "safe," it is just wrong. He was thinking of a completely different situation, namely the quadratic equation.* The best boat is of no use in air travel. Inappropriately he gets security out of fixed rules and dogmas without adapting to the actual situation. Jim is the kind who would say, "what was good enough for my father is good enough for me."

In finding the sum of an infinite progression, we got $1/1-\frac{1}{2}$, which John could not work out, saying "you know, infinity puzzles me." Now infinity had nothing to do with his troubles. What he could not do was computing $1-\frac{1}{2}$, since he always had difficulty with common fractions. After all, it is much less of a disgrace to be puzzled by infinity than by common fractions. John is an impostor, hiding behind big words.

* Compare: Von Domarus' Principle: "Whereas the normal person accepts identity only upon the basis of identical subjects, the paleologician accepts identity based upon identical predicates." (Outside readings in Psychology, Hartley, Birch, Hartley, New York, 1950; p. 611.)

Peter spends most of his time during a test, discovering "misprints" and "unclear wording" in text, even if the problems themselves are completely clear. If he would sincerely analyze the text, it would be fine; instead he dwells on non-essential information, merely to escape doing the problems. Peter will always blame the world for his failings.

I defined the sine for Betty: "the sine of angle A is . . . ;" before I could finish my sentence, she interrupted, "why don't take you angle B?" This would have been a very good remark two minutes later, showing some good mathematical sense. But she was too impatient. Her unwillingness to accept prevents her from learning. Betty is the kind who will substitute criticism for understanding—a species we often find in concert audiences.

Paul, when asked to draw a rectangle, always draws a square. I frequently explained to him that one should plot the most general case. He insists on oversimplification, thereby losing the realistic aspect of the whole problem. Perhaps Paul will never broaden his horizons, for this would make his life too complicated.

Alice could not solve a simple trigonometric problem when we were working in analytic geometry. When I called her attention to the fact that she does know her trigonometry, she realized that she often fails just because she does not expect a situation. Probably Alice will not make a good driver, since there she would have to react quickly to unforeseen circumstances.

Mary could not solve $5A=50$ because an unknown must be called x, not A. In fairy tales and magic thinking names are very essential; but often, and especially in mathematics, the relation is the important thing. Mary, we shall find, is rather conventional, if not superstitious.

III

Our few examples show how certain defense mechanisms and character-traits reveal themselves in the mathematics class, just as they do in every day life. That they do, of course, is not at all surprising, since, although he may not be aware of it, the student carries his total personality with him, even into a math. class. Frequently, we mathematics teachers are sorry our subject lends itself less to personality analysis than some other subjects. My short report is only a little experiment to show that this, after all, is not quite so.

"Ice-cubelet" machine turns out 20,000 cubelets a day for hospitals, restaurants and soda fountains. The small "cubes," said to cool faster and last longer than crushed, chipped or flaked ice, are five-eighths of an inch on a side. Thickness can be adjusted to meet individual requirements.

LOCATING PLACES IS A SKILL

Raus M. Hanson
Madison College, Harrisonburg, Virginia

Schools now encourage the acquiring of many skills. The school leaders have found that the development and use of any skill has the later advantage of saving both time and effort. The list of skills usually includes these: art, music, physical education, number combinations, writing, and reading. The list should also include skills in geography. Map skills are among the ones used in geography; they include both the ones used in preparing maps and in quickly finding the location of places shown on maps.

A person uses a map skill when he draws a map and correctly locates different places on it. In drawing maps, geographers accept that a small circle is usually the mark or sign which shows the location of a city or town. Symbol is another name for that small circle. When preparing a map, skills are practiced in using the accepted symbols for places. Skills are also used in correctly printing names on maps.

A person may need a large map of a given area or state, but the only map which he can find is quite small. If that person is trained in different map skills, he can plan and accurately draw a map several times larger than the smaller one. He may, however, wish a smaller map of the same area. Then, he uses his map skills to plan and draw the map which shows the area in a smaller space on paper. The choice of colors used for a map is as much a skill or an art as the choice of well-selected clothes for a person. Although there are other map skills, this paper is to be limited to the map skills used in locating places.

Four or five different map skills are used in locating places. One is the use of longitude and latitude; a second is using the distance and direction from a well-known city. A third helpful skill is knowing the direction from a specific part of a seacoast from which one may locate a selected nearby town. The location of a place might also be on a river, on a lake, or near a mountain range. A fourth skill uses the continent and the part of the country in which a place is located. Using this information, the student finds the map showing the continent and country; then, he readily locates the looked-for place. This last skill can be used soon after maps have been introduced to a classroom of younger pupils.

Two references are helpful to any person who wishes to save time in locating places. Nearly every school has a *Webster's New International Dictionary—Unabridged.* One helpful reference is the gazetteer which is printed on approximately 140 pages in that dictionary. A person finds on the first page of the gazetteer an explana-

tion of 125 abbreviations which are used in the reference. The 140 pages use the abbreviations. Any person wanting to locate a selected place may use the information given in these abbreviations in order to find in which country the place is located. Then, he may quickly turn to a map showing that country and find the selected place.

An atlas is the second reference which is helpful in saving time in locating places. Each important publisher of maps now has on the market an inexpensive atlas which sells in any book store for less than 75 cents. Atlases use one of two plans in helping a person to locate the place for which he is looking. The index of any atlas gives the name of each place which is shown on maps contained in that book. Each name of a place, given in that index when one plan is used, is followed by three items of information. The three items are: the latitude of the locality, its longitude, and the page which shows that place on a map. The person who is trying to locate a place turns to the index in the atlas and finds the place name. Then, by turning to the given page and by using the latitude and the longitude, he is able to locate the place.

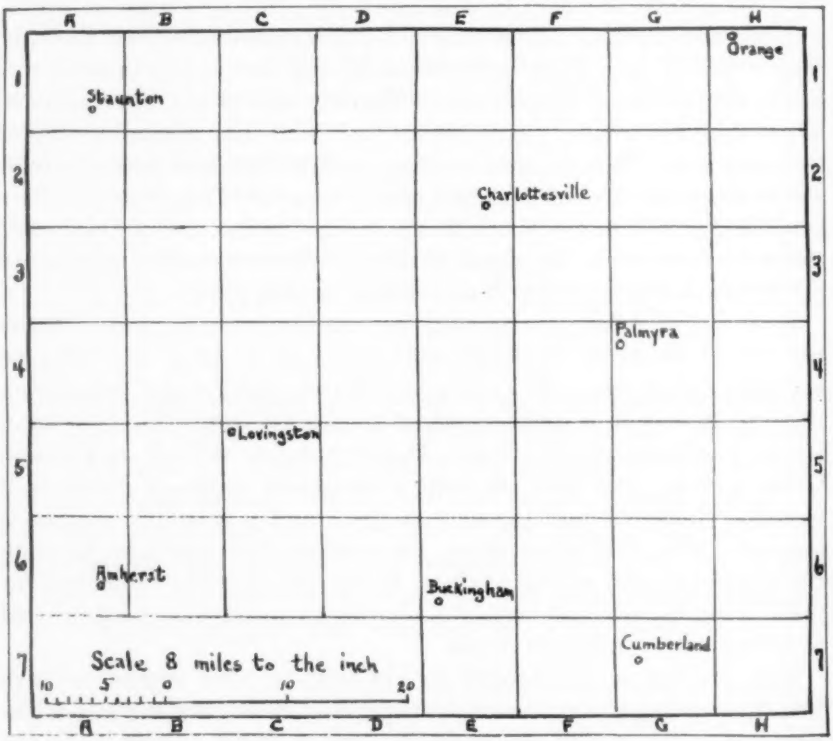

FIG. 1. Map showing plan used in many atlases in locating places.

The other plan used in atlases has each map divided into square spaces that are equal in size. (See Figure 1.) Beginning at the left-hand side, the top of the map has a letter "A" labelling the first space, "B" the second space, etc. The same plan is used for labelling the spaces along the bottom of the map. Beginning at the top of the map, along the left-hand side, the first space is numbered "1," the second space is numbered "2," etc. The same plan is used for labelling the spaces along the right-hand side. A student may use an atlas which has maps divided into spaces labelled in this way. While using this type of atlas, he may, for example, wish to locate Denver. The index of the atlas shows that the city is on the map on page 64 and, on that map, the city is in the space "J-3." He turns to page 64 and locates the line of spaces across the map from "J" at the top to "J" at the bottom. Then, he locates the line of spaces across the map from "3" on the left side to "3" on the right side. One space on that map is in both the "J" row and the "3" row. In this one space, the student can very soon find the location of Denver.

An entire page in a large book may show a map of Africa. One-half of a page in a smaller book may also show a map of Africa. For both maps, a plan was needed in order that the size of the map would have a definite relationship to the size of the part of the earth's surface which it represents. The person who gathers the information needed in making a map needs to have an accurate measurement of the area's size and shape. The actual size of the area, of course, cannot be shown on a map. Then, the map is drawn so it will be a definite fraction of the actual size. The fraction representing the size of an area is called the *scale* of the map. Since the size of the map is a fraction of the actual size of the area, a person can measure distances on a map if he knows what this fraction, or scale, is.

A mile contains 63,360 inches. One type of scale which is frequently used on maps is 1/63,360, or 1:63,360. This means that one inch of measurement on the map represents 63,360 units of the same length on the ground. In drawing maps, the inch is the easiest measurement to use in the scale. With the scale of 1/63,360, one inch on the map represents 63,360 inches on the ground. The unit of measurement on the earth's surface which is easiest to represent on a map is the mile. Using this scale, it is generally written as 1 inch::1 mile. One-half mile is 31,680 inches. Then, the scale of 1/31,680 may be written as 1 inch equals $\frac{1}{2}$ mile, or 2 inches equal 1 mile.

A scale of miles is printed on each map. The scale is a horizontal line or bar on which a series of equal divisions are marked by vertical lines. Each division or part of the bar represents a given number of miles. (See Figure 1.) A student can use a map's scale to locate a

place on that map by a given distance and direction from a well-known city. For example, the student reads that Walla Walla is 220 miles southeast in a straight line distance from Seattle. First, he takes a sheet of paper and places a mark for "zero" on the paper's edge a short distance from one corner. Starting from that mark and using the scale of miles, he measures the distance of 220 miles on the edge of the paper. He places the mark for "0" on the symbol for Seattle on the map. He then lays the paper on the map so that the edge follows a line southeast from that large city. Very close to the 220 mark on the edge of the paper, he will find Walla Walla.

A student finds that books often give the location of places on rivers, lakes, or near other well-known geographical features. He may read that St. Louis is close to the place where the Missouri River empties into the Mississippi. Another page in the book states that Milwaukee is on the western shore of Lake Michigan. On another page, the student reads that Colon is at the eastern entrance to the Panama Canal. He reads that the kingdom of Nepal is on the southern slopes of the Himalaya Mountains. Each of the four examples tells how to find the location of a place from a familiar feature.

The gazetteer has the information that Alexandria is a seaport city on the Mediterranean in Egypt. If Ecuador is to be located the gazetteer tells that the country is in South America. If Juneau is the place to be located, the same reference tells that it is in Alaska in North America.

A person knows either the title or the first line of a hymn. Then, he does not turn one page after another hoping to find the specific hymn in his church hymnal. Instead, the person turns to the hymnal's index and finds the hymn's number. A gazetteer is an index which helps one to locate each important place. If you live in a small town, it may not be listed in the gazetteer of Webster's dictionary. Your county's name, however, with its county seat is given as one of the thousands of places listed in that helpful reference.

A person may be employed as a full-time teacher of music. You notice that person generally has the music before him whenever he is playing, singing, or directing. The musician usually owns an index or a volume of titles for musical compositions. He uses a skill whenever he refers to that special kind of index to find any musical composition in a short time. A person should not be expected to know the location of hundreds of places. Instead, he should use map skills and should know how to use both the gazetteer and the atlas in order to locate any important place. He should develop map skills instead of trying to overload his memory.

SIGNPOSTS TOWARD THE REVISION OF HIGH SCHOOL CHEMISTRY*

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There was a teacher who gave her students an assignment, a review of a book on penguins. In order to stimulate clear thinking, as well as brevity to be sure, she asked that the review be couched in one sentence. From one boy she got this statement: "This book tells me more about penguins than I care to know."

Probably teachers of chemistry would say, and with justice, that they have heard more about the need for revision of chemistry than they care to know. Yet another way of putting it in one sentence would be: Chemistry has a tremendous impact on society but too little impact on registration. That is a pity because chemistry is useful, it is interesting, it is a necessary piece of equipment for boys and girls who would understand modern society.

I shall not labor the last point because it is easy to demonstrate. Rather I should like to examine briefly with you the reasons why a great number of students shun the chemistry classroom. Then, there will be time for an intellectual brawl where the assumptions made will be scrutinized. Concisely, we shall then see what might be done to give most students the opportunities and pleasure which chemistry yields. One way of doing this is to examine some myths upon which our teaching of chemistry depends. At the outset, it must be clear, that the quest for isolation of these myths does not imply infallible judgment on the part of the reagent used in the isolation. I shall deal only with three major myths.

I. *The myth of the selected student body.* A careful examination of courses of study and methods of teaching now employed indicates that chemistry teachers think the student body of a given high school is composed of individuals with I.Q's of 110 or more, or thereabouts and that most, if not all these students, are interested in becoming chemists. Obviously this is not so. Yet the course generally given is aimed at such students.

Most students in our schools cannot learn a vast assortment of facts unrelated to their present lives combined with a private shorthand, a private mathematics, high levels of abstraction, often symbolic and highly theoretical in nature, as well as the laboratory skills which accompany learning in chemistry. It seems clear, therefore,

* Presented at the Chemistry Section of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, Chicago, November 28, 1952. In the absence of Mr. Brandwein the paper was read by another member of the section.

that chemistry registration cannot be high because the number of students who can cope with such a course is not high.

Yet the solution is clear. For those who are to be experts in chemistry, the course in chemistry as given now ought to be extended and enriched—made, if you wish, more abstract, more esoteric and more delightful and exciting to those whose gifts enable them to do so. For those, who are not to become experts in chemistry, a chemistry course suited to their needs and interests is also possible and,indeed, necessary. Such course would deal with the problems these boys and girls will face as citizens,—with topics such as household chemistry, conservation of minerals, the nature of textiles, burning in the furnace, photography, etc. Surely atomic energy would be dealt with in such a course but on a level which satisfies the curiosity of such students, explains theory sufficiently for them to understand newspaper accounts but does not require them to write nuclear reactions and understand fully the theory behind it.

Is this chemistry? Or is it watered-down chemistry? This leads us to the next myth which affects our thinking about the teaching of chemistry.

II. *The myth of the watered-down course.* Let us make short shrift of this. I have taken a good number of chemistry courses through graduate school. I did not find a single course (even those in the Phase Rule and Physical Chemistry) which were not watered down; watered down, that is, from the existing body of knowledge. Every teacher selects from the body of knowledge and every course is watered down. It is better to say the field to be investigated is circumscribed to fit the student body.

It is no sin, if my thinking is correct, to fit one course to students who will be chemists (water down a college course if we must) and fit one course to students who will not be chemists (select materials which will help them solve the problems in chemistry which they will face as human beings).

There is all the difference in the world between teaching chemistry as an end in itself and teaching it as a help in solving problems of living. The first helps the expert, the second helps those who will cooperate with experts.

III. *The myth of the chemistry teachers' strait-jacket.* There is one thing I do know, or I think I know. Talks with teachers indicate that they do want to introduce courses which fit the expert-to-be and the citizen-layman-to-be; that is, they want to introduce courses to fit special education as well as general education. However, they point out that courses of study mandated by state Boards of Education do exist; College Entrance Examinations do exist among many other

pressures. And textbooks are indeed very similar. Agreed, these do exist. But they need not exist forever.

After all, a firm and steady pressure by teachers in the classroom will make itself felt. Sincere rebellion in the interests of the children we teach will make itself felt. Not everything in the textbook need be taught; the textbook is, we must agree, a basic reference—not a strait-jacket. Our textbooks will change as the demand is felt—but even our present textbooks have a great deal of material from which intelligent selection can be made.

I have reason to believe, too, that College Entrance Board Examinations are changing. I refer then to the need for polite, firm, sincere, instructive rebellion in the interests of children and the life they will live.

I think you will agree with me that if one could visit simultaneously, classes in Chemistry I early in September,—at a given time, one might find everyone preparing oxygen, then hydrogen, then studying water—almost an ordained series of events goes on throughout the term. The time is coming when the chemistry course will be answerable only to the kind of community in which the school is to be found, to the kind of life the children will lead, and the ingenuity of the teacher.

We are agreed that chemistry is important to modern life and living. We are agreed that we cannot convince children of its importance to them if they do not come to our classrooms. We are agreed, perhaps, that the answer may vary from school to school. We are agreed, perhaps, that revision in chemistry is needed along two lines; one would result in making chemistry attractive to the expert-to-be; the other to those who will at most have to understand enough to cooperate with the expert and to make choices which will affect life and living. We are agreed, perhaps, that if this last suggestion is not the answer, another answer must be found. To that quest for a satisfactory answer to the problem of the direction of revision of chemistry, teachers should address themselves. Surely the training, the wisdom and the will are present among us. All that remains is to do it.

A NEW DISTRICT MANAGER FOR EBF

Robert Brown, a veteran with the organization and a former teacher, has been appointed district manager for Encyclopaedia Britannica Films, Inc., in the Ohio area, Walter Colmes, president, announces. He will headquarter in Cleveland, at 1860 E. 85th St.

As district manager, Brown will supply Ohio schools with the latest motion pictures and records for use in the growing audio-visual teaching movement. EBF, oldest and largest of the educational film producers, offers more than 600 titles of educational motion pictures, all closely linked with school curricula.

EVENTS THAT LED TO THE DISCOVERY OF PLUTO

James K. Anthony
Southern University, Baton Rouge, Louisiana

Man has always found astronomy to be romantic. As a layman his interest has usually extended no further than the moon; as a scientist then the exterior galaxies have been his goal. To enjoy the moon required only the proper setting and an imagination; to enjoy the latter required a knowledge of advanced mathematics. The early astronomers did not apply mathematics to their observations but they knew their stars and constellations. Six bodies wandered about the heavens and were known to these lonely watchers of the skies, though their true planetary nature was not known.

It was not until the advent of the telescope with its auxiliary instruments that progress was made in planetary astronomy. And by far the greatest achievements have been with the aid of the sister science of mathematics. The planets Mercury, Venus, Mars, Jupiter, and Saturn were known to the ancients but it was Sir William Herschel who discovered Uranus on March 13, 1781 in the constellation of Gemini. This discovery extended the distance of the solar system from 887,000,000 miles to over 1,000,000,000 miles. Computers immediately plotted the orbit of Uranus and its celestial whereabouts could always be found by consulting the *Ephemeris*. Heavenly order and astronomical precision were maintained until it was discovered that Uranus was a bit wayward in its behavior. For instead of being at its predicted spot at any given time, this problem planet would deviate from its orbit some few millions of miles. This, then was a problem for the celestial bureau of investigation composed of those inquisitive investigators—the mathematicians and their *aides de camp*, the amateur astronomers.

Two such men tackled the problem of the irregularities of the motion of Uranus each independent of the other. John Couch Adams, the British mathematician (by preference) and teacher (by necessity) after compiling many formulae sent a statement to the Astronomer Royal, Sir George B. Airy, of his predictions. But since Adams was an unknown mathematician his letter was "pigeonholed" by Airy in favor of his customary afternoon tea. In the meantime Urban Jean Joseph Leverrier of France arrived at the same conclusion that Adams did and he sent his findings to the Berlin Observatory. A newly charted sky map had been completed there and in a short time a new object was discovered in the constellation of Gemini.

The announcement of a new planet electrified the scientific world

and plaudits were heaped upon Leverrier. When the great news reached England Airy recalled that a young teacher of mathematics had written something about a trans-Uranian planet and after searching through a stuffy desk, found the letter sent to him. Shortly thereafter Airy announced that Adams, too, had successfully predicted the location of the new planet. Relations between the British and French scientific societies were strained to the breaking point over which man was to receive the credit of discovery until it was decided to honor both men since each arrived at his conclusions independently of the other and furthermore neither one knew the other was working on the problem.

If the astronomers thought that the discovery of Neptune (as the new planet was called) was the answer to the perturbations of Uranus, their peace of mind was short-lived for it was soon discovered that Neptune's mass and distance from Uranus had a negligible effect upon Uranus and the problem was still unsolved. The events that led to the discovery of a trans-Neptunian planet were as bizarre as they were mathematical; as cryptic as they were scientific. Percival Christopher Lowell was an amateur astronomer and quite wealthy, and first became interested in the questionable surface markings on the planet Mars during the ruddy planet's close approach to the earth at the close of the nineteenth century. Lowell selected a site near Flagstaff, Arizona and built an observatory that now, among other telescopic aids, houses a 42-inch reflecting telescope. Lowell studied the surface markings on Mars and wrote several monographs on them. Then he turned his attention to the possibility of locating a ninth member of the solar system of planets. Lowell died in 1915 but not before he compiled enough mathematical data to locate the trans-Neptunian planet. Fifteen years went by and no planetary discoveries were made.

Clyde Tombaugh was graduated from a Kansas high school in 1930. The class prophecy that was read stated that he would go forth and discover new worlds. Seven months later and working as an assistant at the Lowell Observatory, young Tombaugh stood puzzled over a set of photographic plates in the blink microscope. Photographs taken of certain regions of the sky were compared with photographs taken of the same regions at later dates. Any object in motion would be revealed in a series of such photographs by a change in its position. Upon confirmation several weeks later the Lowell Observatory announced that the ninth member of the solar system has been discovered by Tombaugh.

If the above announcement from the Lowell Observatory was startling to an unsuspecting public, then the behind-the-scenes events were equally surprising. The prophecy had come true. The planet

was discovered at the Lowell Observatory and announced to the world on March 13, 1930, the date of Herschel's discovery of Uranus (149 years earlier) and also the birthday of Percival Lowell. The planet was found near the star Delta in the constellation of Gemini *again* and at one of the two predicted places calculated by Lowell 15 years previously. Finally the name of this ninth planet of the solar system is Pluto—the first two letters of the name are the initials of the mathematical giant whose wisdom and foresight made the planetary theory a reality—Percival Lowell. Coincidence?

CATALOGUE OF EDUCATIONAL AIDS FOR POWER SUPPLIER RURAL PROGRAMS AVAILABLE FROM WESTINGHOUSE

A 12-page catalogue of "Educational Aids for Power Supplier Rural Programs," is available from the Westinghouse Electric Corporation. Described in the catalogue are 38 free and low-cost materials for power suppliers to use in furthering 4-H, Future Farmers of America, Future Homemakers of America, and other rural educational programs.

The catalogue lists booklets and guides for distribution to rural youth, and reference materials for the use of youth program leaders. Included in the material are descriptions of practical demonstrations that rural youth can perform, as well as "how-to" instructions dealing with wiring, electrical apparatus repair, food preparation, lighting, and farm shop work. Also included is a description of four sound motion pictures on electricity and its application to the home and farm. These films are loaned free of charge, or prints can be purchased.

For a copy of the catalogue, B-5864, write School Service, Department T, Westinghouse Electric Corporation, Box 2278, Pittsburgh 30, Pa.

A NEW COMPUTER

It may take you 180,000 times longer to solve a relatively simple arithmetic problem than it does General Electric's new electronic computer.

That's the result of a small contest held here in which half-a-dozen intelligent adults pitted their multiplication skills against "OARAC," the computer which the G-E Electronics Division will deliver soon to the U.S. Air Force's Research and Development Command.

OARAC can multiply 8,645,392,175 by 8,645,392,175 in about four one-thousandths of a second. The answer comes out in quintillions.

An accountant, accustomed to working with numbers, multiplied the figures in four and one-half minutes, the fastest time.

A secretary and a writer took time out from their typing to vie for the slowest time, 12 minutes.

A housewife set aside the vacuum cleaner to make the more than 200 multiplication and addition steps in nine minutes.

The engineer responsible for the design of OARAC did it in five minutes. A trained mathematician got his answer in six minutes.

None of their answers coincided. None of them got the right answer—which is 74,742,805,859,551,230,625, in case you have a pencil and a watch handy.

Gentle Spring, in sunshine clad.
Well dost thou thy power display.—Longfellow.

PROGRESS REPORT*

COMMITTEE ON THE SIGNIFICANCE OF MATHEMATICS AND SCIENCE IN EDUCATION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

The Committee on the Significance of Mathematics and Science in Education was established a little more than two years ago. It was given the charge of determining the reasons for the apparent reduction in enrollment, both numerically and percentagewise, in courses in high-school science and mathematics, and of suggesting ways for bringing the significance of science and mathematics to the layman. In order to pursue the factors implicit in the charge, the following persons were appointed to the committee:

George G. Mallinson
Western Michigan College of Education
Kalamazoo, Michigan

Walter G. Marburger
Western Michigan College of Education
Kalamazoo, Michigan

David J. Miller
Lakeview Junior High School
Battle Creek, Michigan

Gerald Osborn
Western Michigan College of Education
Kalamazoo, Michigan

Donald Worth
Lincoln Junior High School
Kalamazoo, Michigan

In its first deliberations the Committee decided to attack the problem in these three stages:

1. To determine whether the drop in science and mathematics enrollments is real or imaginary.

2. If real, to determine in so far as possible the causes for such a drop.

3. If causes are identified, to present some recommendations that may help to alleviate the problem.

The progress in each of these stages is here reported:

Stage 1: *The reality of the drop in enrollments in science and mathematics.*

a. The drop in enrollments in courses in science have been accepted as a tentative reality by the Committee. This is true both

* Presented at the Friday afternoon meeting of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, November 28, 1952.

numerically and percentagewise. The information that led to this conclusion was obtained from these sources:

1. National Survey of Secondary Education, *The Program of Studies.* Bulletin 1932, No. 17, Monograph No. 19, Office of Education, United States Department of the Interior, Washington, D. C., 1933. Pp. x+340.
2. *The Teaching of Science in Public High Schools.* Bulletin 1950, No. 9, Office of Education, Federal Security Agency, Washington, D. C., 1950. Pp. viii+48.
3. *Offerings and Enrollments in High School Subjects, 1948–49.* Chapter 5, Biennial Survey of Education in the United States in 1948–50. Office of Education, Federal Security Agency, Washington, D. C., 1951. Pp. vi+118.
4. *National Summary of Offerings and Enrollments in High School Subjects, 1948–49.* Statistical Circular, Circular No. 294; Office of Education, Federal Security Agency, May 1951.

It will be noted by those who compare this report with that delivered to the Convention of the Central Association of Science and Mathematics Teachers in Cleveland, Ohio on November 23, 1951, that some new sources of information have been added. It has been the policy of the Committee throughout to revise continually the information used in clarifying various issues of the study. Every attempt has been made to assure that the report will be up-to-date when the final report is made one year hence.

b. The drop in mathematics was not so easy to determine since at the outset of the study there was no information available that was similar to that for the field of science. A number of persons were written when the study was initiated to determine what information might be available. Among them were Mr. Harry Charlesworth, Acting Executive Secretary of the National Council of Mathematics Teachers, Dr. Mayor of the University of Wisconsin, Dr. Fehr of Columbia University and Dr. Fawcett of the Ohio State University. All these men indicated that there were no extensive studies that dealt with the changes in enrollments in mathematics during the past years.

Thus the Committee sought to obtain information from primary sources where possible and to defer this part of the study until later when such information might be available. Fortunately, a number of sources of information bearing on the problem have appeared since that time. They are as follows:

1. A bulletin of the U. S. Office of Education entitled *Offerings and Enrollments in High School Subjects.* This bulletin provided a limited amount of information with respect to present enrollments in courses in high-school mathematics.

2. All the statistical divisions of the forty-eight states were written asking for any information they might have concerning enrollments in the various courses in high-school mathematics over the past thirty years. Less than half the states had information available

and most of those that did, did not have it in summaries. Some states employed a number of clerks and statisticians to summarize the information for thirty years back. In the case of other states, it was necessary for the Committee to synthesize the information in the bulletins. The states from which extensive information was obtained are Oregon, New York, Montana, West Virginia, Vermont, New Hampshire, Massachusetts, Minnesota, Missouri and New Jersey.

3. A conference held with Kenneth Brown, Specialist in Mathematics of the U. S. Office of Education on November 14, 1952 revealed that further information prepared by the Office of Education concerning this problem will be available within a month. This information will be used to supplement that which the committee has already assembled.

In general, it was found that enrollments in high-school courses in mathematics, as with the field of science, are on the decline both numerically and percentagewise. Hence, the next step was to determine possible causes.

Stage 2: *Determining possible causes for the decline in enrollments.*

a. It was believed that one matter worthy of investigation was the subject-matter backgrounds of teachers in science. It was believed that if the subject-matter backgrounds of such teachers are insufficient to assure their competence in science, the students are not likely to be motivated to take advanced courses in science. The investigations, which in the interest of brevity are not herein identified, indicate clearly that the subject-matter backgrounds of student teachers in science are not likely to be as broad or as comprehensive as may be desirable.

b. It was decided also to determine whether or not the state requirements for certifying teachers of high-school science might be enough to assure their subject-matter competence and hence be an influence in Item *a* in this section. Several studies were also undertaken in this field and it was found that state requirements for certification are not as comprehensive as suggested by major committee reports or as indicated as being suitable for assuring subject-matter competence.

c. A third investigation was undertaken to locate information concerning certification requirements for teachers of high-school mathematics. This information was obtained from magazine articles and by writing the various states. At the present time this information has not been analyzed. It will be in the near future and will be used to supplement the information already obtained.

In addition to this information, Mr. Worth received information

from Dr. H. H. Irwin, Professor of Mathematics, State College of Washington, that members of the Northwestern Section of the American Mathematical Association had already made a study of State Certification Requirements for Secondary School Mathematics Teachers and that their data and conclusions appear to have a direct bearing on our work.

Briefly, they found that many states require for teacher certification in mathematics, a minimum of 18 hours or more of college training in the field, but that in some states this requirement ran as low as 8 hours. In still others a teacher could teach mathematics with no preparation in college mathematics whatsoever as long as this subject was assigned to him by his principal.

The conclusion reached from this study was that much of the difficulty in high-school mathematics teaching arises, not in the deficiencies of college mathematics training programs, but rather from the great variation in certification requirements prescribed by State Boards of Education.

d. Another study was undertaken by a member of the Committee to determine the course requirements that are established by the various states for graduation from high school. This extensive study, undertaken by Mr. Worth, has been completed and it indicates quite clearly that subject-matter requirements in science and mathematics are considerably less than those for social studies or for English. The data obtained are too extensive to list here. They will, however, be included in the final report.

e. Another study was undertaken by Mr. Harold Van Dragt of Belding High School, Belding, Michigan to determine whether or not the interests of students in science and mathematics change over the high school period. It was found that the interests of students do change to a considerable extent and in general their interests in science and mathematics are more likely to decline than to increase.

f. Another study is being undertaken to determine the types of backgrounds that are ordinarily found in a representative sampling of guidance counselors in the various high schools in the Midwest. The data is already in the hands of the Committee and will be analyzed in the near future.

The members of the Committee do not wish to state that they believe that the various investigations necessarily indicate definite causation for the drop in enrollments. However, they hope that when all the studies are completed they may be able to draw certain conclusions with respect to cause. The techniques of the investigations, of course, will be given more specifically in the final report.

Stage 3: *Recommendations for indicating the significance of science and mathematics in education and for increasing enrollments.*

It has been recommended already to certain officers of the Central Association of Science and Mathematics Teachers that the final report be prepared in bulletin form for presentation to the CASMT at its convention one year hence. It is hoped in that bulletin (1) to report the findings that have been made in the investigations undertaken by the Committee and (2) to make certain recommendations for stimulating enrollments in the various courses in science and mathematics and for improving them.

This progress report is being submitted for the approval of the Central Association of Science and Mathematics Teachers.

George G. Mallinson
Walter G. Marburger
David J. Miller
Gerald Osborn
Donald Worth

EASTERN ASSOCIATION OF PHYSICS TEACHERS ONE HUNDRED EIGHTY-THIRD MEETING

Saturday, Mar. 22, 1952

Brandeis University
415 South St.
Waltham, Mass.

Theme: Seeing a New Institution.

10:00 A.M. Greetings, Head of the Department of Publicity
10:15 A.M. Dr. Saul Cohen, "Brandeis and the Science Program"
11:00 A.M. Dr. Robert Thornton, "The Humanistic Approach to the Teaching of Science"
12 NOON Tour of the University
1:00 P.M. Lunch in the Cafeteria
2:00 P.M. Business Meeting

The talk given by Dr. Saul Cohen told those present of some of the problems in setting up a science program for the first time in a new institution. Everything had to be cut to fit both the institution and the pupils. Discoveries were made in the process that indicated where other courses may lend help in the preparation of the student for that which is to come. This worked both ways. The science courses had opportunities to assist assisting courses.

The title of the talk by Dr. Thornton was changed to essentially "Analysis and Use of Transfer of Training."

General education makes use of the assumption that learning is a transferable quality. What intellectual habits, conceptual skills, and special techniques are involved in this transfer of training? Transfer seems to take place best where there has been consciously generalized method in the intellectual technique. We

start with three tentative assumptions: (1) It is possible to define, describe, and teach transferable intellectual habits. (2) If such transfer were a main concern of teachers in basic science courses, from 25 to 50% of the time now spent in repeating introductory assumptions could be saved; hence, in the same curricular period much more could be accomplished. For instance, if students learn to recognize generalizations and to think about the nature of evidence in any course, they can continually apply these skills elsewhere. (3) The content of a curriculum should be selected in terms of method rather than in terms of facts or tradition. . . . Once this hypothesis is taken as a basis for procedure, the problem evidently becomes: How is method best taught?"

Skilled teachers effect transfer without explicit knowledge of the methods used. Transfer is not achieved as a result of preaching transfer, the student must see that the methods of analysis he has learned in some other place may have application to more than one situation. When it is possible, the basic aspects of the scientific method in use should be carefully identified. Transfer takes place when there are common intellectual habits and these common habits must be pointed out to the student.

Many habits can be taught, and the habit of using definitions is basic to science. He who has learned to use definitions as instruments of analysis, may be able to apply this method to a variety of situations.

Intellectual habits vary in their seeming difficulty. At some levels, the basic arithmetical facts, mechanical learning is all that is needed. To have a liberal education presumes understandings as well as knowledges.

Another general skill that can be taught is the ability to ask oneself, what biases and preconceptions do I have that lead me to make incorrect estimates in my analysis? Perhaps the unorthodox but valid may then be more readily accepted.

Science makes use of another skill that may be taught, that is explanations by means of analogy. The beginning of explanation is the identification of similarities. Physical models are often used in place of words in the teaching of science. It should be established that there is possible fallibility in certain particulars with any model or pattern of analogy.

In physics, the student learns many general rules. Some students are apt to become lost when confronted with the specific problem. They recognize the general but cannot interpret the specific. "The pressure of the American educational system has been towards the debasement of learning into the memorization of a set of unconnected propositions, suitable for the purpose of objective testing." The text book trained student has great difficulty in the analysis of a concrete situation in the terms of the text propositions. The better student, when given some clue, has little trouble in selecting the relevant and logical propositions. "Systematic analysis of the relevance and pertinence of evidence would demand among other things a self-conscious examination of the nature of extrapolation and the recognition and analysis of the validity of anologies. These are clearly key problems of all science. . . . " There are many who never learn of the existence of these techniques.

ALBERT R. CLISH, *Secretary*

EASTERN ASSOCIATION OF PHYSICS TEACHERS
ONE HUNDRED EIGHTY-FOURTH MEETING

Joint Meeting with

The New England Biological Association

and

The New England Association of Chemistry Teachers

Saturday, May 10, 1952

The College of the Holy Cross
Worcester, Mass.

10:00 A.M. Welcome, Rev. John A. O'Brien, S.J., President
10:15 A.M. "The Practice of Crystallization in the Laboratory and the Plant," Prof. Andrew van Hook, The College of the Holy Cross
11:15 A.M. "Introduction to Chelating Agents, with an Application to Industrial Problems," Mr. Harold Marcus, President, Electrochemical Industries Inc., Worcester
12:15 P.M. Annual Meeting
1:00 P.M. Lunch
2:00 P.M. "Kodachrome Studies of New England Wild Flowers," Dr. Robert A. Steele, Worcester

There were no physics aspects in this meeting that need reporting.

ALBERT R. CLISH, *Secretary*

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2330. *Charles G. Pitner, Leary, Ark.; Walter R. Warne, Syracuse, N. Y.; John Britton, Britton, Mich.; Samuel Wickes, Trumansburg, N.Y.; Simon Ritter, East Varick, N.Y.; Roger J. Newman, Jackson, Miss.; Walter A. Stahl, Cleveland, Ohio.*

2331. *Martin Schmookler, Scranton, Pa.*

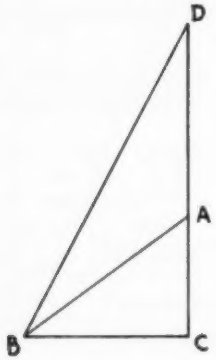
2332. *Martin Schmookler, Scranton, Pa.; Rogers J. Newman, Jackson, Miss.; A. R. Haynes, Tacoma, Wash.; Walter A. Stahl, Cleveland, Ohio.*

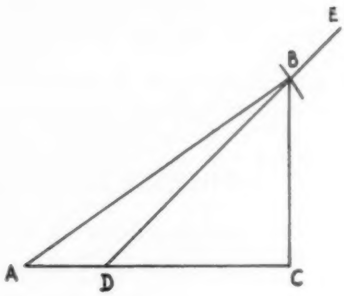
2335. ***Proposed by Clara Bonard***

Construct the right triangle, given any median any two ex-circle radii.

Solution by Leon Bankoff, Los Angeles, Calif.

Because of a superfluity of given data, we can construct triangles using 21 different combinations of necessary elements selected from those given. After eliminating those clmbinations which involve duplicated construction procedures, we have remaining essentially twelve distinct problems, which may be classified in three categories as follows:





A) Construct a right triangle, given any two ex-radii.
 Case I. r_2, r_3, $C=90°$ (or, r_1, r_3, $C=90°$)
 Case II. r_1, r_2, $C=90°$

B) Construct a right triangle, given any median and any ex-radius.
 Case I. m_c, r_3, $C=90°$
 Case II. m_c, r_2, (or r_1), $C=90°$
 Case III. m_a, (or m_b), r_3, $C=90°$
 Case IV. m_a, r_1, $C=90°$ (or m_b, r_2, $C=90°$)
 Case V. m_a, r_2, $C=90°$ (or m_b, r_1, $C=90°$)

C) Construct a triangle, given any median and any two ex-radii.
 Case I. m_c, r_3, r_2 (or r_1)
 Case II. m_c, r_1, r_2
 Case III. m_a, r_1, r_2 (or m_b, r_1, r_2)
 Case IV. m_a, r_1, r_3 (or m_b, r_2, r_3)
 Case V. m_a, r_2, r_3 (or m_b, r_1, r_3)

The simplest constructions are those in category A).

Case I. Construct a right triangle, given r_2 and r_3 ($C=90°$).

Draw $BC=r_3-r_2$. At C erect a perpendicular to BC and lay off $CD=r_3+r_2$. Find the point A on CD such that $\angle ABD=\angle BDC$. ABC is the required triangle. This construction is based on the knowledge that, in right triangles, $r_2=s-a$ and $r_3=s$. Whereupon $r_3-r_2=a$ and $r_3+r_2=2s-a=b+c$.

Case II. Construct a right triangle, given r_1, r_2, $C=90°$ ($r_2>r_1$).

Draw $AD=r_2-r_1$. Draw DE making an angle of 135° with AD. With A as center and with radius (r_1+r_2), describe an arc cutting DE in B. A perpendicular from B cuts AD produced in C. ABC is the required triangle. Since $r_2=s-a$ and $r_1=s-b$, we have $r_2-r_1=b-a$. Also, $r_1+r_2=2s-a-b=c$. With the hypotenuse and the difference of the legs known, the construction is elementary.

Solutions were also offered by: Miss Elmira Willey, Morenci, Mich.; Benj.

Moffat, Sterling, N.Y.; Flood King, Lexington, Ky.; Blanche Gilgen, New Ulm, Minn.; Harry Kohler, Brooklyn, N.Y.

2336. *Proposed by C. W. Trigg, Los Angeles City College.*

If $N=M^KP$, then N has a factor $\leqq N^{1/(K+1)}$.

Solution by the Proposer

If $P=M$, then $M=N^{1/(K+1)}$.
If $P>M$, say $P=M+R$, then $N=M^{K+1}+M^KR$, so $N>M^{K+1}$ and $M<N^{1/(K+1)}$.
If $P<M$, say $M=P+S$, then $N=P^{K+1}+f\ P,\ S)$, so $N>P^{K+1}$ and $P<N^{1/(k+1)}$. This proves the proposition.

In the special case, $K=1$, since N has a factor $\leqq\sqrt{N}$, one need consider only the primes $<\sqrt{N}$ as possible factors. For example, if it is desired to factor 163, only 2, 3, 5, 7 and 11 need be considered as possible factors. Clearly 163 is divisible by none of these, so it is prime.

Similarly, for $K=2$, if N has a square factor, it has a factor $\leqq\sqrt[3]{N}$. $|\sqrt[3]{1121}|=10$. Since 1121 is not a multiple of 2, 3, 5 or 7, it has no square factor.

Solutions were also offered by: J. H. Means, Austin, Tex.; Roy Wild, University of Idah; Leon Bankoff, Los Angeles; Julian H. Braun, Washington, D.C.

2337. *Challenge—let's have a solution.*

2338. *Proposed by Richard H. Bates, Milford, N. Y.*

Show that the difference between the squares of any two primes is divisible by 8.

Solution by Boyd Henry, Fairfield, Iowa

The proof which follows will show that the statement is true for any two odd integers, hence is true for odd primes.

If a and b are two unequal positive integers, then $(2a+1)$ and $(2b+1)$ are necessarily odd numbers. The difference of their squares is given by

$$\begin{aligned} d&=(2a+1)^2-(2b+1)^2\\ &=4a^2+4a-4b^2-4b\\ &=4[a(a+1)-b(b+1)]. \end{aligned}$$

Whether a is odd or even, the product $a(a+1)$ must be even. Likewise $b(b+1)$ must be even. Then let

$$a(a+1)=2m,\qquad b(b+1)=2n$$

then

$$d=4(2m-2n)=8(m-n).$$

Solutions were also offered by: Benjamin Greenberg, Ramax High School; Eman W. Guyer, Brooklyn, N. Y.; Julian H. Braun, Washington, D. C.; Francis Blessing, New York; Robert Glahn, Kirksville, Mo.; Richard H. Bates, Milford N. Y.; J. H. Means, Austin, Tex.; H. R. Smith, Pas-A-Grille Beach, Fla.; Charles McCracken, Jr., Cincinnati; Ronald Henderson, Farmington, Ill.; David Rappaport, Chicago; Leon Bankoff, Los Angeles; Ernest H. Kanning III, Valpariso, Ind.; Margaret F. Willerding, St. Louis; Rex Wood, Elmore, Mich.

2339. *Proposed by Leon Bankoff, Los Angeles.*

Show that

$$\theta=\sin 2\theta-\frac{\sin 4\theta}{2}+\frac{\sin 6\theta}{3}-\frac{\sin 8\theta}{4}+\cdots$$

for

$$-\frac{\pi}{2}<\theta<\frac{\pi}{2}.$$

Solution by Julian H. Braun, Washington, D. C.

In the expansion

$$\log(1+z)=z-z^2/2+z^3/3-z^4/4+\cdots \qquad |z|<1 \qquad (1)$$

put $z=\cos 2\theta+i\sin 2\theta$ where $\theta\neq(n+\frac{1}{2})\pi$.

The natural logarithm of a complex number is given by

$$\log(A+Bi)=\tfrac{1}{2}\log(A^2+B^2)+i\tan^{-1}(B/A).$$

Hence $\log(1+z)$ reduces to

$$\log(1+\cos 2\theta+i\sin 2\theta)=\tfrac{1}{2}\log\left[(1+\cos 2\theta)^2+\sin^2 2\theta\right]+i\tan^{-1}\frac{\sin 2\theta}{1+\cos 2\theta},$$

$$=\tfrac{1}{2}\log(2+2\cos 2\theta)+i\tan^{-1}\left(\frac{2\sin\theta\cos\theta}{2\cos^2\theta}\right),$$

$$=\log|2\cos\theta|+i\tan^{-1}(\tan\theta). \qquad (2)$$

By substitution of value of z above, in right member of (1) we obtain

$$\log(2\cos\theta)+i\tan^{-1}(\tan\theta)=\cos 2\theta+i\sin 2\theta-\frac{\cos 4\theta}{2}-\frac{i\sin 4\theta}{2}+\frac{\cos 6\theta}{3}+\frac{i\sin 6\theta}{3}$$

$$-\frac{\cos 8\theta}{4}-\frac{i\sin 8\theta}{4}+\cdots.$$

In (2) the *principal value* of the arc tangent is implied; hence, if $-\pi/2<\theta<\pi/2$, then $\tan^{-1}(\tan\theta)=\theta$. Thus, substituting in (2) and equating imaginary parts gives

$$\theta=\sin 2\theta-\frac{\sin 4\theta}{2}+\frac{\sin 6\theta}{3}-\frac{\sin 8\theta}{4}+\cdots \qquad -\frac{\pi}{2}<\theta<\frac{\pi}{2}.$$

It may also be of interest to note that the equating of the real parts gives

$$\log|2\cos\theta|=\cos 2\theta-\tfrac{1}{2}\cos 4\theta+\tfrac{1}{3}\cos 6\theta-\tfrac{1}{4}\cos 8\theta+\cdots \qquad \theta\neq(n+\tfrac{1}{2})\pi.$$

Solutions were also offered by Roy Wild, University of Idaho and the proposer.

2340. *Let's have a good solution to this one.*

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2338. *Robert L. Parker, Bethany, Okla.*

PROBLEMS FOR SOLUTION

2353. *Proposed by Norman Kesoner, Brooklyn.*

Inside a regular hexagon *ABCDEF*, a point O is located so that *OB, OC, OD* are respectively

$$5, \frac{4\sqrt{3}}{3}, 3$$

in length.

Find the area of the hexagon.

2354. *Proposed by C. W. Trigg, Los Angeles City College.*

Show that $(N^4-2N^3+11N^2+14N+24)/24$ is an integer for N positive.

2355. *Proposed by Dwight L. Foster, Florida A&M.*

Two circles touch at C, and a point D is taken without them so that radii AC, CB subtend equal angles at D. If DE and DF be tangents, prove by geometry that $DE \cdot DF = DC^2$.

2356. *Proposed by Hugo Brandt, Chicago.*

From Kasner and Newman's "Mathematics and the Imagination"

About a circle with radius $r_2=1$ circumscribe an equilateral triangle, and about this triangle another circle (radius r_3). Now circumscribe a square about the latter circle, and a circle (radius r_4) about the square. Continue similarly with regular polygons of 5, 6, etc. sides. Find the limit which r_n approaches as n approaches ∞.

2357. *Proposed by Dwight L. Foster.*

If $\sin A = p \sin B$, $\cos A = q \cos B$, $\sin A + \cos A = r(\sin B + \cos B)$, prove that $(p-r)^2(1-q^2)+(q-r)^2(1-p^2)=0$.

2358. *Proposed by Jessie Sheridan, Conning, N. Y.*

Prove:

$$(2-1/n)(2-3/n)\cdots\left(2-\frac{2n-1}{n}\right)>1/n.$$

BOOKS AND PAMPHLETS RECEIVED

SCIENCE IN EVERYDAY LIFE, by Ellsworth S. Obourn, *Head of Science Department, John Burroughs School, Clayton, Missouri;* Elwood D. Heiss, *Professor of Science New Haven State Teachers College, New Haven, Connecticut;* and Gaylord C. Montgomery, *Instructor of Science, John Burroughs School, Clayton, Missouri.* Cloth. Pages viiii+612. 15.5×24 cm. 1953. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $3.80.

A SCHOOL COURSE IN MECHANICS, PART I, by A. J. Bull, M.A., *Assistant Mathematics Master, Bryanston School.* Cloth. Pages viii+156. 13.5×22 cm. 1952. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. Price $1.75.

MATHEMATICS OF FINANCE, by Lloyd L. Smail, Ph.D., *Professor of Mathematics, Lehigh University.* Cloth. Pages x+282. 15×23 cm. 1953. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $4.50.

THE RADIANT UNIVERSE, by George W. Hill. Cloth. Pages xv+489. 14.5×23 cm. 1952. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $4.75.

FRENCH INVENTIONS OF THE EIGHTEENTH CENTURY, by Shelby T. McCloy,

Professor of History at the University of Kentucky, Lexington, Kentucky. Cloth. Pages viii+212. 15×23.5 cm. 1952. The University of Kentucky Press, Lexington, Ky. Price $4.50.

ARITHMETIC FOR HIGH SCHOOLS, by Professor Charles H. Butler, *Department of Mathematics, Western Michigan College of Education, Kalamazoo, Michigan.* Cloth. Pages xv+336. 12.5×20.5 cm. 1953. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.40.

HEALTH AND FITNESS, Second Edition, by Florence L. Meredith, B.Sc., M.D., *Late Professor of Hygiene and Public Health, Tufts College;* Leslie W. Irwin, Ph.D., *Professor of Health Education, School of Education, Boston University;* and Wesley M. Staton, Ed.D., *Associate Professor of Health and Physical Education, University of Florida.* Cloth. Pages x+339. 17×23 cm. 1953. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.20.

SOLID GEOMETRY, A CLEAR THINKING APPROACH, by Leroy H. Schnell, *State Teachers College, Indiana, Pennsylvania,* and Mildred G. Crawford, *Roosevelt School, Michigan State Normal College, Ypsilanti, Michigan.* Cloth. Pages x+198. 15×23 cm. 1953. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.20.

THE LEARNING OF MATHEMATICS, ITS THEORY AND PRACTICE. TWENTY-FIRST YEARBOOK. Cloth. Pages ix+355. 15×23 cm. 1953. The National Council of Teachers of Mathematics, Inc., 1201–16th Street, N.W., Washington 6, D. C.

ORGANIC CHEMISTRY, by Melvin J. Astle, Ph.D., *Associate Professor of Organic Chemistry,* and J. Reid Shelton, Ph.D., *Professor of Organic Chemistry, Case Institute of Technology, Cleveland, Ohio.* Cloth. Pages x+771. 15×23.5 cm. 1953. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $7.50.

AN INTRODUCTION TO MATHEMATICAL THOUGHT, by E. R. Stabler, *Department of Mathematics, Hofstra College.* Cloth. Pages xviii+268. 14×21.5 cm. 1953. Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. Price $3.00.

THE COMPOSITION AND ASSAYING OF MINERALS, by John-Stewart-Remington, and Dr. Wilfrid Francis. Cloth. Pages viii+127. 13.5×21.5 cm. 1953. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $5.50.

THE ATOM STORY, by J. G. Feinberg, M.Sc. Cloth. Pages vii+243. 13.5×21.5 cm. 1953. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

SOLID GEOMETRY, by William G. Shute, William W. Shirk, and George F. Porter, *Instructors in Mathematics, The Choate School, Wallingford, Connecticut.* Cloth. Pages vii+280. 14×21.5 cm. 1953. American Book Company, 55 Fifth Avenue, New York 3, N. Y. Price $2.48.

PLANE GEOMETRY, A CLEAR THINKING APPROACH, by Leroy H. Schnell, *State Teachers College, Indiana, Pennsylvania,* and Mildred G. Crawford, *Roosevelt School, Michigan State Normal College, Ypsilanti, Michigan.* Third Edition. Cloth. Pages xii+436. 15×23 cm. 1953. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.20.

ELEMENTS OF THE THEORY OF FUNCTIONS, by Konrad Knopp, *Professor of Mathematics at the University of Tübingen* and Translated by Frederick Bagemihl. Paper. 140 pages. 13×20.5 cm. 1952. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.25 paperbound, $2.25 clothbound.

WHAT IS SCIENCE, by Norman Campbell, Sc.D. Paper. 186 pages. 13×20.5 cm. 1952. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.25 paperbound, $2.50 clothbound.

THE THEORY OF ELECTRONS AND ITS APPLICATIONS TO THE PHENOMENA OF LIGHT AND RADIANT HEAT, by H. A. Lorentz. Second Edition. Paper. 343 pages. 13×20.5 cm. 1952. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.70 paperbound, $3.50 clothbound.

LECTURES ON CAUCHY'S PROBLEM IN LINEAR PARTIAL DIFFERENTIAL EQUATIONS, by Jacques Hadamard, LL.D., *Member of the French Academy of Sciences, Foreign Honorary Member of the American Academy of Arts and Sciences.* Paper. Pages v+316. 13×20.5 cm. 1952. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.70 paperbound, $3.50. clothbound.

PHOTOGRAPHY WORKBOOK, by Victor C. Smith, *Ramsey Junior High School, Minneapolis, Minnesota.* Paper. Pages vii+83. 21×27.5 cm. 1953. J. B. Lippincott Company, 333 West Lake Street, Chicago 6, Ill.

ELEMENTS OF MATHEMATICS, by Helen Murray Roberts, and Doris Skillman Stockton, *University of Connecticut.* Paper. Pages vii+211. 16×25 cm. 1953. Addison-Wesley Publishing Company, Inc., Cambridge 42, Mass. Price $3.00.

DISCOVERING ARITHMETIC, Book 2, Teachers Edition, by Catherine Stern. Paper. 224 pages. 20×28 cm. 1952. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.60.

THE JOB AHEAD FOR DEFENSE MOBILIZATION. Eighth Quarterly Report to the President by the Director of Defense Mobilization, January 1, 1953. Paper. Pages iv+51. Superintendent of Documents, U. S. Printing Office, Washington 25, D. C. Price 30 cents.

SCIENTIFIC PERSONNEL EMPLOYMENT BULLETIN. Current Scientific Vacancies in Naval Activities, January 1953. 45 pages. 19.5×26 cm. Prepared by Civilian Personnel Division, Office of Naval Research, Department of the Navy, Washington, D. C.

SCIENCE FACILITIES FOR SECONDARY SCHOOLS, by Philip G. Johnson and Others. Misc. No. 17. Paper. Pages vi+38. 23×29 cm. 1952. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25 cents.

DIRECTORY OF SECONDARY DAY SCHOOLS 1951–52, by Mabel C. Rice, *Supervisory Survey Statistician, Research and Statistical Standards.* In Consultation with the Secondary School Section. Paper. Pages xviii+167. 23×29 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price $1.00.

BOOK REVIEWS

ROCKS, RIVERS AND THE CHANGING EARTH. A FIRST BOOK ABOUT GEOLOGY, by Herman Schneider and Nina Schneider. Cloth. 181 pages 15×21.5 cm. 1952. William R. Scott. Inc., 8 W. 13th Street, New York 11, N. Y. Price $3.00.

A first book about geology and written for boys and girls in late elementary grades. By simple text, numerous line drawings of the van Loon type and—a rather surprising inclusion of some fifteen or twenty simple experiments, these authors present this, number eight, of their learning by doing and by looking books.

The four parts are: Land Torn Down; Sea Filled In; Land Built Up and Man and the Earth. Relative stress is indicated by chapter distribution; six in part one; one each for parts two and four and four for part three. Each chapter is sub-divided into captioned parts of three or four paragraphs each. A six page

double columned index provides ready access to the book's information. Illustrations are neither numbered or referred to in the index. A worthy book for any school library.

B. CLIFFORD HENDRICKS
457 24th Ave., Longview, Wash.

THE ATMOSPHERE, by Peter Hood. Cloth, 64 pages. 17×23 cm. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $2.50.

This is a second volume of a series of picture books on subjects connected with physical and natural sciences. The first of the series was Observing the Heavens and those in preparation include How the Earth is Made; Life in Fresh Water and the Insect World. The authors promise to give simple introductory presentations suitable for young people and others who want exact and serious information and who may find that they learn better if they can look as well as read. Roughly twenty-five per cent of the large sized pages are devoted to excellent figures both of drawn and photo type. Some are in color. Where specific weather or climatic types are detailed those common to the British Isles are used. Simple aids to its use include a brief Table of Contents and a page of Books for Further Reading. There is no index. This book is a splendid piece of workmanship both from the standpoint of the printer and the educator.

B. CLIFFORD HENDRICKS

A NEW CALCULUS, PART III, by A. W. Siddons, K. S. Snell, and J. B. Morgan *Assistant Masters at Harrow School.* Cloth. Pages vi+463, 13.5×21.5 cm Cambridge University Press, American Branch, 32 East 57th Street, New York, 22, N. Y. Price $3.75.

This British text seems to cover topics in a different manner than most American books. It covers some topics found in our elementary calculus books, and some ordinarily found in what we would term an "advanced calculus." To select a few topics of somewhat more elementary nature: differentials, hyperbolic functions, inverse circular functions, partial fractions, integration by parts, infinite integrals, reduction formulas, arc length, multiple integrals; on the somewhat more advanced side: envelopes, Leibniz' theorem for the nth derivative of a product, differentiation of a determinant, definite integrals of powers of sin x and cos x between limits 0 and $\pi/2$, Green's theorem, Fourier series, uniform convergence, higher order differentials, indeterminate forms by expansion into series. There is a rather extensive treatment of differential equations, including a discussion of operators, series solutions, numerical approximations, and some elementary partial differential equations.

Although the emphasis is somewhat on the side of application, there is some sound mathematical theory, and a very large number of problems (with answers) which in many cases involve rather difficult manipulation. With both text and problems one finds thought provoking questions raised—as a single example, the statement that "positive direction" along a curve may have different meanings for different independent variables. As might be expected, in a few spots one finds a wording that may seem odd to the American reader—the *gradient* of a curve; "curly" dV by dr given as the way a partial derivative symbol is read.

Probably few colleges will find this a textbook which fits the course offered, but certainly it would be a valuable reference in the library, both for the student and the instructor.

CECIL B. READ
University of Wichita

THEORY OF NUMBERS, by B. M. Stewart, *Associate Professor of Mathematics, Michigan State College, East Lansing, Michigan.* Cloth. Pages xiii+261.

13.5×21 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.50.

In the preface the author points out that this book is planned as a textbook for advanced undergraduate and beginning graduate students, with an effort to provide in each of the thirty-three chapters material of such nature that the essential portion can be covered in a fifty-minute period. Although the extent of coverage possible in such manner will vary, it would seem that he has to an exceptional degree succeeded in reaching his objective—writing a text book neither "too short nor too long, too easy or too advanced, for a short course" (to quote the author).

One particularly commendable feature consists of footnotes at the beginning of each chapter, pointing out whether the chapter is basic to the understanding of later work, or whether some or all of the material might be omitted without omitting topics essential for later chapters.

This is frankly not a reference work, but a textbook; in the opinion of the reviewer it is one of the best available for a short course. Opinions as to the merit of a text vary, no teacher wishes to adopt a text without examination; but this is a book deserving careful consideration. Some idea of the content can be obtained by listing certain topics selected at random—by no means is this complete: the division algorithm, mathematical induction, the Euclid algorithm, the fundamental theorem of arithmetic, prime and composite integers, number-theoretic functions, matrices and determinants, Diophantine equations, Fermat's method of descent, congruences, quadratic residues, Peano's axioms for the natural integers, fields and domains, continued fractions.

CECIL B. READ

UHF PRACTICES AND PRINCIPLES, by Allan Lytel, *Lecturer in Electronics, Temple University Technical Institute.* Cloth. Pages ix+390. 14×21 cm. 1952. John F. Rider Publisher, Inc. 480 Canal Street, New York 13, N. Y. Price $6.60.

UHF refers to the Ultra High Frequency band of wavelengths between 1.0 and 0.1 meters in the radio frequency spectrum of wavelengths, used more and more for point to point communication and new television channels. This book is designed to provide the fundamental background for an understanding of the techniques used in uhf transmitting and receiving equipment. The experimental stage in the development of these frequencies is about outgrown, so that increased usefulness in applications awaits those who are adequately informed.

Because the ultra-high frequencies require special techniques, concepts, and circuits, the electronic technician must keep abreast of uhf developments. This book presupposes a familiarity with fundamentals of standard broadcast equipment, taking the student or technician by a logical sequence from known techniques to the new concepts needed for uhf. The first three chapters discuss the nature of ultra-high frequencies and how they differ from lower frequencies. In clear, non-mathematical language, the new problems of skin effect, inductive-capacitive circuit components, and transit time of electron flow in vacuum tubes are introduced and their over-all effects noted and explained. On almost every page can be found simple diagrams, and when available, photographs of actual equipment to supplement the word descriptions.

A very notable contribution is the simple but complete treatment of antenna systems in practical applications. The treatment is entirely descriptive with brief developmental theory. A thorough description of the operation of transmission lines and wave guides is given in a manner that even the uninitiated can understand.

Since new types of tuned circuits are required, uhf oscillator tubes and circuits are included. TV converters and receivers for uhf are investigated and practical types are illustrated.

The student can profit by the clear presentation, the sample practical problems, and the review questions at the end of each chapter. The technician can

bring his knowledge up to date as well as use the book for reference purposes concerning uhf circuits, practices and test equipment.

O. F. WARNING
Lyons Township High School and Junior College

COMMERCIAL ALGEBRA, by Robert M. Parker, *Assistant Professor of Mathematics, Texas Technological College.* Cloth. Pages vii+263. 14.5×22 cm. 1952. American Book Company, 55 Fifth Avenue, New York 3, N. Y. Price $3.25.

This book is apparently designed as a text in college algebra primarily for students in the field of business administration. There seems to be ample material included for a three-semester-hour course, even though a two- semester-hour course probably could be based on this text with proper selection of material.

The reviewer finds a few illustrations of unusual and, in some cases, incomplete definitions. On page 1, negative numbers are defined as opposites of the corresponding positive numbers without any further explanation of the word opposite. On page 53, the statement is made, "The principal even root of a negative number is called an *imaginary number.*" The statement following this indicates, "All other numbers are defined as *real numbers.*" Does it follow then that the even roots of a negative number other than the principal even root of a negative number are all real? Although the author is very careful when giving the definition of a zero exponent, page 54, to exclude the value of zero for the base, he fails to place the same restriction in defining negative exponents. The description of a mantissa given on page 63 seems adequate except to point out that the statement, . . . "*for numbers having the same sequence of digits the fractional part of the logarithm is the same,*" is true only when the fractional part has the same sign in all cases. However, the examples given in this section are written so that the mantissas are positive. There is an apparent misprint in the last paragraph on page 77, "First divide each term of the equation by 2 so that the coefficient of x will be 1."

Many of the topics included in this book are the same as those ordinarily included in a treatise on college algebra. However, many of the problems are appropriately selected from the field of business. As might be expected in a book of this type topics dealing with simple and compound interest and discount, statistics, and probability are given considerable emphasis, while other topics such as inequalities and partial fractions are omitted entirely. Review lists of problems are included at the end of every third chapter. Five tables are included in the back of the book.

It should not be implied that this text is particularly bad. Certainly much of the material appears to be carefully and appropriately selected. Further consideration might be given this text for those responsible for the selection of a college algebra for classes comprised exclusively of business students.

J. RAY HANNA
University of Wichita

MATHEMATICS OF FINANCE, by Edwin D. Mouzon, Jr., *Professor and Chairman of the Department of Mathematics, Southern Methodist University,* and Paul K. Rees, *Associate Professor of Mathematics, Louisiana State University.* Cloth. Pages viii+255+147. 15.5×22.5 cm. 1952. Ginn and Company, Statler Building, Boston 17, Mass. Price $4.60.

This is a text designed for a course in the mathematics of finance or investment requiring as a prerequisite no more than one semester of college algebra. The authors have considered the usual topics including: simple interest and discount, compound interest, annuities certain (including the general case annuites), amortization and sinking funds, depreciation, bonds, life annuities and life insurance. A few topics such as force of interest and reinvestment rates apparently are not discussed.

Italics are used frequently for emphasizing defined words. Answers are given to nearly all the problems. Summaries, which frequently include lists of formulas, are given at the end of each of the chapters. Problem lists appear quite adequate to provide ample drill for the student and allow the instructor to select several lists of problems without undue repetition. Review lists of problems also appear at the end of each chapter. Appendices are included on topics relative to exponents and logarithms, progressions and binomial theorem.

With few exceptions, tables are collected in one location in the back of the book. The tables entitled, "Number of Each Day of the Year" and "Bond Table" are located with related material. A good selection of interest rates ranging from $\frac{1}{4}\%$ to $8\frac{1}{2}\%$ is given for the usual functions. The 1941 CSO Mortality Table is used for the work on life annuities and life insurance. Five place logarithms are included.

The equation of value is perhaps introduced at an earlier stage in this book than is the usual practice. Frequent use is made of the line diagram. Perpetuities are first discussed in connection with a study of simple interest. Later it is pointed out that the present value of an ordinary annuity can be thought of as the difference between the present values of two perpetuities, one having payments deferred for n periods.

Although the authors state that this book furnishes adequate material for a three-hour semester course, it seems feasible that material could be selected from this book to serve for a two-hour course as well. This text might well merit further consideration for anyone planning an adoption.

J. Ray Hanna

Practical Calculus, Second Edition, by The Late Claude Irwin Palmer, *Armour Institute of Technology, Chicago, Illinois*, and Claude E. Stout, *Professor of Mathematics and Engineering Mechanics, General Motors Institute, Flint, Michigan.* Cloth. Pages xx+470. 11×19 cm. 1952. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $6.00.

This book is designed as a text in calculus primarily for students in technical institutes, for home study, and for refresher study. Sufficient material seems to be included to provide a year's course in elementary calculus of perhaps three or four hours per week.

Only minor changes have been made in this edition over the original edition, *Practical Calculus for Home Study*, by The Late C. I. Palmer. A few illustrative examples have been replaced with new examples. Some problem lists have been revised. Perhaps the greatest content change involves the addition of some new topics concerning space coordinates, approximate integration, Newton's method of approximating the solution of a numerical equation, and differential equations. Probably one of the primary purposes of this edition is to introduce an active sponsor of the original Palmer text.

The unified presentation of differentiation and integration is preserved in the second edition as it was in the first edition. The topics included in this book are much the same as those ordinarily treated in elementary calculus texts. Most problem lists seem quite adequate to provide the student with ample drill. Applied problems have been selected from a wide variety of fields. Answers are given to many of the problems in the back of the book. There is also in the back of the book an appendix of tables and formulas. Use of the notation ln u has been avoided. The discussion of series seems a little inadequate due large to the secondary emphasis placed on the idea of convergence and divergence. In most cases, an apparent effort has been made to formulate explanations that are as non-technical as possible, yet still retain accuracy and clarity.

Although this book could be used as a text in a course in a liberal arts college, it would perhaps seem to be a more feasible selection for a course in a technical college. Serious consideration might be given this book as one to be recommended

to students wishing to refresh or engage in self-instruction in calculus, particularly if a few topics might be supplemented.

J. RAY HANNA

QUANTITATIVE ANALYSIS, First Edition, William Marshall MacNevin *Professor of Analytical Chemistry*, and Thomas Richard Sweet, *Assistant Professor of Analytical Chemistry* both of the *Ohio State University*. Cloth. Pages ix and 247, 13.5×21 cm. 1952. Harper and Brothers, 49 East 33d Street, New York 16, Price $3.75.

The preface states, "This book supplies a need for a short text in quantitative analysis." This statement is not accurate as there are several short texts available. The authors could have stated that this book supplies the need for a *good* short text. This reviewer found much to commend this modern text to the attention of teachers of analytical chemistry. It would prove to be a real help to the student both in the lecture and in the laboratory. It is written in a readable, straightforward style. Theoretical material is kept at a minimum, but all the necessary basic theory is adequately treated. The authors have wisely elected to defer the teaching of physical chemistry until the student registers for a course under that name. Questions and problems are meant to be helpful, not tricky.

All the time-tested gravimetric and volumetric determinations that most teachers prefer to use are clearly described in this text. In addition there a number of modern determinations to choose from: Iron in alloys by photometry, pH both colorimetric and potentiometric, sulfate by ion exchange, and total hardness by versenate.

The printing and format of this book are excellent.

SHIRLEY WALTER GADDIS,
Westminster College, Fulton, Missouri

A GENERAL ZOOLOGY OF THE INVERTEBRATES, by G. S. Carter, *Fellow of Corpus Christi and Lecturer in Zoology in the University of Cambridge*. Cloth. Pages xviii+509. 13.5×21.5 cm. 1948. Sidgwick and Jackson Ltd., London. Price $5.75.

This book was written to serve as a reference guide for the advanced students of invertebrate zoology, its terminology and discussions assuming that the students already have some knowledge of the subject. The emphasis here is on animal biology and ecology rather than on systematics and morphological characters.

"Life is another name of the properties of protoplasm," wrote Julian Huxley in the introduction to the book. "Thus the first task of a writer on invertebrate zoology is to discuss the main properties of animal protoplasm and to describe the organization of the typical animal cell. His next step will be to demonstrate the variety of forms assumed by free-living animal cells, the degree of size and complexity of which they are capable, and the types of organs capable of being differentiated within single cells."

Those words describe, in brief, the purpose and scope of the book. It starts with a section devoted to protoplasm and the free-living cell, then describes the multicellular body. The third section treats comparative physiology: respiration, nutrition, excretion and osmotic control, co-ordination, receptor organs, effector organs, and the physiology of sponges. The fourth, and final, section deals with life histories of the invertebrates, their behavior, habits, and evolution.

It is an excellent addition for every biology reference library, as a companion book for the standard texts on the invertebrates.

GEORGE S. FICHTER
Oxford, Ohio

BASIC BIOLOGY FOR HIGH SCHOOLS, Revised Edition by Carroll Lane Fenton, Ph.D., and Paul E. Kambly, Ph.D., *Professor of Education and Director of*

Supervised Teaching, University of Oregon. Cloth. Pages ix plus 726. 14.5×21.5 cm. 1953. The Macmillan Company, 60 Fifth Avenue, New York 11, New York.

This is a textbook of biology which purports to cover the essentials of the subject as demanded by a one-year course without making of the book "both a textbook and a source of supplementary reading." The material has been "selected, tested, and selected again to make sure that it develops the topics accepted as fundamental both by biologists and by teachers. . . . " It is organized in such a manner, with questions, suggested projects, supplementary readings, and discussion topics, to assist the students in the development of the scientific method of inquiry and pattern of thought. The type and the illustrations are printed in a sepia-toned ink to produce a book which is easy-on-the-eye. All in all, it is a well-organized assembly of material.

The final section is devoted to the subject of conservation of our natural resources and is a notable addition to the contents of the book. It gives the students an opportunity to apply the information they have just acquired. Some of the concepts contained therein are, however, of necessity treated too lightly to give the students the sort of thinking on the subject which they should have. For example, there is a liberal usage of the word "balance"—that mythical state of harmony in Nature. Most present-day biologists would as soon avoid its use, for there is no "balance" of the sort often implied. Nature exists and thrives on an out-of-balance condition, which sometimes concerns and disturbs the life-ways of man. The conserving of fish and wildlife takes on the typical scolding pattern of "we have wasted; now let's herd the remaining animals into refuges and restock the open areas." This, too, is an antiquated—and perhaps harmful—approach. The authors have placed in the book the sort of conservation thinking which was accepted and practiced fifteen or twenty years ago. Much progress has been made since then. In general, of course, the final answers and the need for attention to the problems are similar enough, and it is good to have such a section—which admirably stresses the point that ***conservation is human conservation.***

This is a good book for classroom use or reference shelf.

George S. Fichter

The Teaching of Secondary Mathematics, New Second Edition, by Charles H. Butler, *Professor of Mathematics, Western Michigan College of Education,* and F. Lynwood Wren, *Julia A. Sears Professor of Mathematics, George Peabody College for Teachers.* Cloth. Pages xiv 550. 15×23 cm. 1951. McGraw-Hill Book Co., 330 West 42nd St., New York 18, N. Y. Price $4.75.

The first edition of this very successful book was published in 1941. The discussion of the teaching of secondary mathematics has been organized in three main divisions in both the first and new second editions. In Part I, The Place and Function of Mathematics in Secondary Education, the discussion should be of special interest to students of education in general. While in Part II, The Improvement and Evaluation of Instruction in Secondary Mathematics, consideration is given to problems which concern the administrator and supervisor in their efforts to improve instruction in secondary mathematics. In part III, The Teaching of the Special Subject Matter of Secondary Mathematics, the problems of instruction in arithmetic, algebra, geometry, trigonometry, and calculus are discussed.

The form and framework of the first edition is kept intact in the new second edition. However, Chapters II, IV, and VI, have been largely rewritten to include developments in the last few years. Attention is given to the increasing emphasis upon general education and upon the use of multisensory aids in teaching. The lists of exercises at the ends of the chapters have been revised, and the chapter bibliographies have been brought up to date.

This textbook maintains a sane and well balanced position between the professional and the academic points of view in the teaching of mathematics.

It contains a gold mine of excellent material not only for mathematics teachers, but for students of education, administrators, and supervisors. Every teacher of secondary mathematics should put this book on his "must" list for reading. Written by two experienced and capable teachers, this book deserves the highest words of praise.

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ALFRED P. SLOAN FOUNDATION AND FOUR TECHNOLOGICAL INSTITUTIONS ANNOUNCE NEW NATIONAL SCHOLARSHIP PROGRAM

Announcements are being sent today to some 35,000 educators throughout the nation about a new series of four-year scholarships for undergraduate students in technology and allied fields, it was announced by the Alfred P. Sloan Foundation and the heads of four of the nation's leading technical institutions, viz., California Institute of Technology, Carnegie Institute of Technology, Cornell University College of Engineering and the Massachusetts Institute of Technology. The new program, financed by the Foundation, will be administered by the four institutions.

The scholarships will be known as the Alfred P. Sloan National Scholarships in honor of the founder and head of the Sloan Foundation.

Recipients will be selected on a national basis from applications received by all four schools.

"A Sloan National Scholarship," the Foundation said in its announcement of the new program, "will be considered by the Foundation and by the participating institutions to be an academic honor of national importance and therefore of lifelong significance to the holders."

Recipients will be men judged by the Foundation and the participating institutions to be of "high character, sound personality, leadership potential, and scientific promise."

Winners of Sloan Scholarships will receive awards ranging from honorariums of $200 per year for those not in need of financial assistance, to amounts of $2,000 per year which will cover tuition, room, board, travel, and miscellaneous expenses.

In addition to these direct awards to the students, the Sloan Foundation will provide an average allotment of $650 per year to each institution for each Sloan National Scholarship in effect there. By supplementing the normal tuition income, this plan will actually provide for the full cost of educating Sloan Scholars at each school. Thus, the school's general funds will not be burdened by the award of this scholarship aid.

In announcing the Sloan National Scholarships, Alfred P. Sloan, Jr., President of the Foundation and Chairman of the Board of General Motors Corporation, said, "It is our purpose to find and gather together on each of these four campuses outstanding representatives of American youth, regardless of their economic background, who show exceptional scientific promise and capacity for leadership. We are as anxious to find the so-called 'rich' boy as we are the 'poor' boy; it is the man that is important."

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